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Recent General Trends in Mathematics: PROFESSOR ARISTOTLE D. MICHAL 563

Precious and Semi-Precious Jewels—Their Chemical and Beautifying Qualities: PROFESSOR R. NORRIS SHREVE 566

Obituary:
Charles William Woodworth: PROFESSOR E. O. ESSIG. *Recent Deaths* 570

Scientific Events:
The War and the British Fauna; The Herbarium of the New York Botanical Garden; The Anniversary of the Institute of Experimental Medicine in Leningrad; Conference in Honor of Leta S. Hollingworth; The Willard Gibbs Lectures of the American Mathematical Society 572

Scientific Notes and News 575

Discussion:
The Sleep of Canaries: DR. GUSTAV ECKSTEIN. *The Etiology and Treatment of Dental Caries:* DR. ROBERT M. STEPHAN. *Significance of Disseminated Metallic Sulphides in Sedimentary Rocks:* DR. F. M. VAN TUYL. *Vitamin Study at the University of Texas:* PROFESSOR ROGER J. WILLIAMS. *The Quinine Industry:* NORMAN TAYLOR 577

Scientific Books:
Regional Physiography: DR. ELLIS W. SHULER. *Plant Physiology:* PROFESSOR JOHN W. SHIVE 580

Reports:
Philanthropic Foundations: DR. FREDERICK P. KEPPEL 581

Special Articles:
The Quantum of Sensory Discrimination: PROFESSOR S. S. STEVENS and DR. J. VOLKMANN. *A New Estrogenic Substance Present in the Neutral Fraction of Human Pregnancy Urine:* DR. RALPH I. DORFMAN. *Concentration and Partial Purification of Equine Encephalomyelitis Vaccines:* DR. JOSEPH W. BEARD and OTHERS 583

Scientific Apparatus and Laboratory Methods:
An A-C Powered pH Set: CRAIG W. GOODWIN 587

Science News 8

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RECENT GENERAL TRENDS IN MATHEMATICS[1]

By Professor ARISTOTLE D. MICHAL

CALIFORNIA INSTITUTE OF TECHNOLOGY

EXCEPTING some comparatively isolated researches in elementary geometry and algebra, mathematical research in the first decade of the twentieth century was largely concerned with subjects whose roots were in the theory of functions of real or complex variables and in a large number of special functional transformations of such functions. It is true that in both America and Europe, the mathematical world was then dimly aware that there was such a thing as a theory of functions of abstract (or general) variables, but outside of a few distinguished workers, notably E. H. Moore in America and M. Fréchet in Europe, no one seemed to have done anything about it. This trend towards general function theories made itself felt during the next two succeeding decades in certain branches of functional analysis, topology and algebra. It was not, however, until the last ten years that general analysis and general algebra permeated, or at least influenced, practically every nook and corner of mathematics and symbolic logic. The American and Polish schools of abstract thought have played a leading role in this development. It is gratifying to see that a large number of young men in American centers of learning are making important contributions to general analysis and general algebra. In the interest of clarity it should be remarked in this connection that excellent progress has been made during the last decade in the theory of functions of real and complex variables and their application to various topics in functional equations, to the calculus of variations and to classical differential geometry. The point we wish to emphasize here, however, is that much of this progress was directly or indirectly inspired by ideas current in general analysis.

One of the reasons why general analysis and general algebra are so far-reaching and very concrete indeed when understood is that one can, by special interpretation of a few general variables and operations, obtain old as well as numerous new results by methods that brush aside the unessential and historically acci-

[1] An address delivered by invitation at the University of Illinois, April 30, 1940.

dental. For example, theorems on functional equations $y=f(x)$ in abstract linear metric spaces can by a few master strokes be made to furnish results in such diversified fields as simultaneous equations in real, complex and hypercomplex variables, ordinary differential equations, partial differential equations and integral equations.

One of the most dramatic examples of the influence of general function theory on a branch of mathematics is furnished by coordinate geometry and differential geometry in particular. The words and phrases coordinates, coordinate systems and transformations of coordinates are on the lips of every student that takes the most elementary college mathematics courses. I say "on the lips of every student" but not "understood by every student" for the simple reason that these notions have only recently emerged from prison walls of philosophical and physical fog into the clearer realm of mathematical thought. It must be recalled that previously the same prison walls had kept fettered the whole subject of geometry until the dawn of our present century, when it became increasingly clear that geometries as mathematical subjects must be developed from a set of postulates concerning classes of more or less undefined (abstract or unspecified) objects. The points of a geometry are undefined, but so are certain distinguished coordinate systems. For example, in plane Euclidean geometry of freshman and sophomore fame, a rectangular cartesian coordinate system is a name given to a postulated single valued function $x(P)$ defined over the whole Euclidean plane and having values in the class of matrices $x=(x_1, x_2)$ with real number elements x_1 and x_2, called rectangular cartesian coordinates of the point P. The function $x(P)$ of the abstract variable P is one of a class of such functions that satisfies a few well-known postulates—and outside of the properties demanded by these postulates, the function $x(P)$ is unspecified. In other words, a rectangular cartesian coordinate system is a mathematical "camera" that photographs the whole Euclidean plane and produces a photograph containing the whole world of matrices $x=(x_1, x_2)$. The nature of this mathematical camera is left unspecified—it is merely required to do the job in a manner specified by the postulates. Other coordinate systems, such as polar coordinate systems, are defined by functions of type $f(x(P))$, where $f(x)$ has arguments and values in subclasses of the class of matrices $x=(x_1, x_2)$. We shall not pursue the subject further —our main object here was merely to indicate how fundamental general function theory is even for the elements of plane Euclidean geometry.

We have already alluded to the influence of general function theory on differential geometry. General function theory enters the subject of finite dimensional differential geometry via the theory of topological spaces and especially through Hausdorff topological spaces. A Hausdorff topological space H consists of a class of undefined elements, called points, and supports a topology determined by a class of undefined subsets of H, called neighborhoods, associated with each point of H such that the following four postulates are satisfied: (1) a neighborhood contains the point of which it is a neighborhood; (2) each point contained in an arbitrarily chosen neighborhood can be surrounded by a neighborhood that is contained in the chosen neighborhood; (3) the intersection of two neighborhoods of a point contains a neighborhood of the same point; (4) each of two distinct points can be surrounded by a neighborhood having no points in common with the other neighborhood. A simple example of a Hausdorff topological space is furnished by the Euclidean plane when neighborhoods of a point P are taken to be the interiors of concentric circles with center at the point P. A coordinate system in a finite dimensional differential geometry is a function $x(P)$, usually required to be a homeomorphism, defined on a subset of a Hausdorff topological space and having values in an n-dimensional arithmetic space, called coordinate space, with points $x=(x^1, x^2, \ldots, x^n)$. In other words $x(P)$ maps a portion of the Hausdorff topological space into a set contained in a class of one-rowed matrices with n real number elements. It is convenient for what we shall have to say later, and in conflict with the usual terminology, to *define the coordinate of a point P* in a coordinate system $x(P)$ to be *the corresponding value of the function* $x(P)$. A coordinate of a point in an n-dimensional geometry *is then*, according to our new terminology, *a one-rowed matrix* of n real numbers. The classical differential calculus for real functions of several real variables now enters the stage and is applied to the differentiability of the components of postulated geometric objects (for example, the components $g_{ij}(x^1, \ldots, x^n)$ of the fundamental metric tensor field in a Riemannian differential geometry) and to the differentiability of the functions involved in transformations of coordinates.

As is to be expected, general function theory plays an even more extensive role in infinite dimensional functional differential geometries. A *coordinate* of a point of a Hausdorff topological space H is now an element of a function space so that a coordinate system $x(P)$ maps a portion of the geometric space H into a class of functions contained in a function space. The differential calculus that is employed in these studies is the classical differential calculus of *functionals*. By a functional we mean here a function whose arguments and values lie in function spaces of functions of a finite number of real variables.

Above all, the influence of general function theory in differential geometry has been felt most strongly in general (abstract) differential geometry, a branch of mathematics which is still in its infancy but which we are convinced is destined to become one of the great

branches of mathematics, comparable to the present status of general (abstract) algebra and general analysis. By a *general differential geometry* is meant a differential geometry with an abstract coordinate space. These geometries are *dimensionless* in the sense that the dimensionality of the coordinate space is left unspecified. This makes possible the inclusion of large portions of finite dimensional as well as of infinite dimensional differential geometries as instances of general differential geometries. The abstract coordinate space must be capable, however, of supporting an appropriate abstract differential calculus. It is for this reason that, in the present state of knowledge, the permissible coordinate spaces are topological abelian groups: linear topological spaces and linear metric spaces (Banach spaces). If a general differential geometry has a Banach space as a coordinate space, a coordinate system $x(P)$ maps a portion of the geometric space, a Hausdorff topological space, into a portion of the Banach space, while a transformation of coordinates $\bar{x}=f(x)$ maps a portion of the Banach space into a portion of the Banach space. The function $f(x)$ must in addition have suitable differentiability properties in accordance with the notions of the Fréchet differential calculus of functions with arguments and values in Banach spaces. This makes possible the study of a general tensor analysis and its application to the subject on hand.

One of the interesting features of the work in general differential geometry is that it suggests new advances in the abstract differential calculus, and in abstract differential equations in particular, at almost every turn of the geometrical theory. To a certain extent this is analogous to the situation that must have existed at the time of Gauss and Riemann in finite dimensional differential geometry and the classical differential calculus. Another interesting feature is the large number (roughly 100) of postulates that is required for any one brand of general differential geometry—say, a general Riemannian differential geometry. This is to be contrasted with the handful of postulates required in abstract algebra, say, in group theory.

Mathematical research has profited greatly in the past by the union of two great streams of mathematical thought to form a new vigorous branch of mathematics. Abstract algebra, especially abstract groups, and abstract topology furnish excellent illustrations. What would be more natural than to take the postulates for an abstract group, to add to them the postulates for a topological space and then to require that the group operations be continuous with respect to the postulated topology? The hybrid object that is obtained in this way is now called an (abstract) *topological group*. During the last decade, topological algebras and especially topological groups have been studied with much success for their own sake as well as for the sake of their applications to other branches of mathematics. We have already spoken of the place of topological abelian groups in general differential geometry. This modern work on topological groups has done much recently to clarify Lie's theory of finite continuous groups. There is now in the literature the beginnings of a general theory of continuous transformation groups in abstract spaces with an abstract parameter. The real flavor of Lie's theory lies in its three fundamental theorems, in its differential operators and their commutators and in its structural constants. With the aid of the abstract differential calculus, a certain amount of success has been met in keeping the flavor of the Lie theory in the general theory of continuous transformation groups with abstract parameters. Much remains to be done here.

The applications of group theory are varied and many. The group-theoretic foundations of various elementary geometries have been studied for quite a long while. During the last decade or two much progress has also been made in group-theoretic studies in algebraic geometry and differential geometry. Even if the geometric space of a differential geometry does not have a non-trivial group of automorphisms, there are group-theoretic problems of some importance that arise in such geometries. These considerations would necessitate a radical revision of the seventy-year-old Erlanger Programm. The applications of group theory to physics have been numerous during the last ten years, especially in the quantum mechanics of many electron atoms and of polyatomic molecules. Continuous groups have been used very little in engineering. However, during the last decade many advanced branches of mathematics have found important applications in engineering, and one may suspect that continuous groups would be found helpful in attacking some of the more difficult problems of elasticity, hydrodynamics, aeronautics and meteorology.

There is another aspect of group theory, however, which in recent years has become fascinating. I am speaking here of the applications of various branches of mathematics to group theory. Of course, the application of differential equation theory to continuous groups is well known and we have spoken of the application of topology to continuous groups. Not so well known is the study of topological groups with the aid of the results of modern differential geometry. In fact, a finite dimensional coordinate topological group furnishes a most beautiful and important example of a non-Riemannian geometry, and it becomes Riemannian whenever the group is semi-simple. The theory of integral equations and the modern theory of integrals has been found useful in compact groups. There is a branch of abstract algebra called lattice theory by some and structure theory by others. A lattice is really a generalized Boolean algebra or a generalization of the algebra of point sets. The way

in which lattice theory enters into various branches of mathematics is briefly as follows. Many fundamental theorems in a mathematical discipline often deal directly with distinguished subsets of elements rather than with the elements themselves. Now these distinguished subsets in various mathematical domains are found to possess common properties. So there is value in studying a discipline in which an undefined element is abstracted from a distinguished subset of elements of a totally different discipline—and that is what lattice theory does. For example, invariant subgroups are such distinguished subsets of elements in group theory. It is problematical, however, whether pure lattice theory would in the future have as much influence on group theory as some other branches of mathematics have already had.

There are very few branches of mathematics that have not been applied to the solution of problems in the pure physical, biological and social sciences, and the day is dawning when the same could be said about the engineering sciences. I mean this statement to be as sweeping as possible; for there are indications in the scientific literature that show that advanced portions of function space theory and non-linear functional equation theory will, with all their topological paraphernalia, become very useful in practical engineering problems.

Physical and astronomical research from ancient times to the present era has exercised a potent influence on mathematical research. This influence has often been in the form of hunches and heuristic guides. An admirable illustration of this is furnished by the choice of appropriate boundary conditions for a partial differential equation, say, for those equations occurring in potential theory. All this has been common knowledge for many years. There is another side to this influence of physics on mathematics that is not so well known and is taking place right before our eyes. I am referring to some of the misconceptions of physicists that have led mathematicians to start interesting mathematical researches. An excellent example is furnished by the so-called ergodic hypothesis of the classical statistical mechanics. Physicists now seem to be unanimous in their opinion that there is no known physical system that operates under the ergodic hypothesis. Even a hasty survey of the recent mathematical literature shows, however, that mathematicians were first led to the study of the so-called ergodic theorems on linear transformations by their own curiosity concerning the ergodic hypothesis. Another illustration is furnished by the numerous abortive attempts of physicists to manufacture unified field theories in general relativity. All these attempts at a unified field theory seemed to be physically vacuous or untenable, and yet some of the most beautiful work by mathematicians in the field of modern differential geometry was directly inspired by such misconceived attempts.

In conclusion, we would like to make a few more remarks concerning this present-day trend towards more abstract and general work in mathematics—a trend that results more and more in the omission of the real number system as a necessary part of many mathematical disciplines, and a trend that points the way to the Olympian heights of the stately mountain peaks that loom in the ever-widening horizon of the mathematical world. Until rather recently, many mathematical concepts such as limit point, open set, closed set, continuity, differentiability—just to mention a few—were thought to be intimately connected with the real number system. We now know that such is not the case and that these concepts have natural domains of existence that are much more general than real number domains. The methods of proof used in real number theory often have to be radically changed so as to conform to the more general patterns. All this is interesting, and frequently great difficulties arise in the proofs of theorems; but the more novel and often highly original aspects of a general theory are met in the situations which have no real number analogues or in those whose real number analogues are trivial—the latter cases are frequently accompanied by a large number of non-equivalent concepts that become equivalent whenever the domains are specialized to number domains. We have already mentioned the novel contributions of the general theories to the real variable domain and we need not dwell on it here, but merely mention it for the sake of completeness.

PRECIOUS AND SEMI-PRECIOUS JEWELS—THEIR CHEMICAL AND BEAUTIFYING QUALITIES[1]

By Professor R. NORRIS SHREVE
PURDUE UNIVERSITY

IN the time before records primitive man searched for the beautiful and rare. When we come to early writings we read descriptions of gems, and we find examples of these in ancient burials. As man became more civilized, this search for jewels went on with increasing eagerness. Accompanying these early discoveries, and perhaps as a mark of their unusualness,

[1] Lecture illustrated by specimens, delivered before Sigma Xi at Purdue University, Indiana University and Union College, and before the Rochester and Cornell sections of the American Chemical Society.

superstition grew up and clustered around these gems. If any think this has died out we need only to call to mind that there are still intelligent people who will not wear opals, considering them bad luck. In less civilized days men and women ascribed all kinds of miraculous attributes to gems, for instance, it being commonly accepted that if one carried a ruby with him, in case of a fall there would be no injury.

Here in Sigma Xi we are interested in research—the understanding of the present and the development of the new. In the field of our jewels, by the application of the usual principles of scientific analysis and classification, man has been successful in unraveling the determinative qualities of the principal gems. He has also succeeded over the past thirty years in outdoing nature by the making of certain gems, such as rubies, sapphires and spinels. The methods of approach have been the same as in other endeavors. First came careful analysis of the chemical and physical qualities which give to gems their striking properties, such as color, fire, hardness and the like. Then in the chemist's laboratory synthesis was undertaken to duplicate what was found in nature. Finally, the third step of development, or improvement, was undertaken, until now in the field of corundum and spinel gems we have the synthetic sapphires, synthetic rubies and synthetic spinels, which are the same as the natural in their essential properties, and which excel the natural in variety of color. These synthetics are not imitations, but duplicates of the natural gems. Recently we hear of synthetic emeralds. The story is only started, as our research has but touched the fringes of the possible in this field. Such analysis and synthesis has greatly increased our understanding of the entire domain of jewels, natural and synthetic, and the underlying causes of their beauty, and why they are prized and sought after.

Let us see what a jewel is and what are its outstanding characteristics of beauty! Let us list these attributes as found in our gems:

(a) *Beauty of color:* This may be natural and inherent (idiochromatic) as occurs in lapis lazuli, malachite, turquoise and hematite. This type of color is based on the very nature of the mineral, and is destroyed if the composition is changed. On the other hand, there are the great majority of jewels in which their beautiful color is due to an "impurity." Here the gem is colorless when pure (allochromatic), and among this type occur many of our finest gems, as sapphire, topaz, emerald, aquamarine, amethyst and agates.

(b) *Beauty of structure:* Irregularities within the jewel are responsible for some of the most prized effects, such as inclusions, bands and fibrous arrangement.

Inclusions occurring in a systematic manner are the foundation of the rare asterisms, as seen in the star sapphire and the star ruby. When these inclusions are formed in a dendritic or tree-like manner in the agate, we call this moss agate.

Banding of color arrangement causes much of the attractiveness in agates, malachite and onyx, and is the basis of the carving into cameos and intaglios.

Play of colors is due to internal irregularities leading to light interference, and forms the soft radiance of the pearl, or the gorgeous and changing color sequences of the opal.

Chatoyance is owing to a fine fibrous structure, and is the velvety appearance seen in tiger's eye (crocidolite) and satin spar.

(c) *Beauty of luster:* This is that phenomenon of light thrown off from the surface, largely caused by brilliance of reflection and high index of refraction, and resulting in the adamantine luster of the diamonds and the resinous luster of amber.

(d) *Beauty due to fire:* The wide dispersion of light, exemplified in diamonds and zircons, causes those color flashes of clear fire that are judged by many to be one of the chief attributes of beauty of our jewels.

(e) *Beauty due to transparency:* Being able to see into the "depths" of a stone enhances its other qualities and lends to its value. We can better appreciate the beauty of transparency by considering how we avoid the opposite or a muddy stone.

(f) *Durability or hardness:* Jewels to be prized must be sufficiently hard to be durable. The extreme hardness of the diamond maintains its high worth through the years.

(g) *Rarity:* This psychological value is very real. There are still, and always will be, people who will gladly pay for rarity. The ruby commands a ready market at a hundred times the valuation of its counterpart in the synthetic field.

The *precious* stones—the emerald, ruby, sapphire, diamond and pearl, with perhaps the opal, are those that possess these various characteristics of beauty to the fullest extent; *that* is why we call them the precious stones. The semi-precious gems are less rare, or less durable, or possess in somewhat smaller degree some of the characteristics we have just enumerated.

BEAUTIFYING CONSTITUENTS

It is very striking to observe that the quality distinguishing one gem from another or of a gem itself from an otherwise simply interesting mineral, is, in most instances, caused by the presence of a small amount of some material that imparts color, or other pleasing characteristic. The few idiochromatic, or self-colored stones, are exceptions. The asterism, so highly prized in the star sapphire, is caused by minute inclusions that reflect the light in such a manner as to give this star effect. These included or color-imparting materials are rated as the minor constituents

in the composition, and are often called the impurities. I myself much prefer to speak of these minor constituents which, for instance, change an otherwise almost worthless bit of beryl into that most valuable of gems, the emerald, as the *beautifying constituents*.

Thus, as we correlate the chemical structure with the pleasing characteristics that give gems their value, we find that we are interested in two ways: First, in the chemical composition of the mineral to which the gem belongs, and second, in these beautifying constituents or so-called impurities. The diamond possesses in an unexcelled degree the characteristics that we have enumerated as gem qualities. Chemically, the diamond is one form of the element carbon, but even here in very unusual instances we will find the most prized diamonds to be those which have a gorgeous color superimposed on the usual fine gem characteristics of this form of carbon. We will possess, for example, in the rare red or blue diamond, a stone with color added to the usual luster, and fire, and transparency. This color is caused by the presence of the beautifying constituent in very small amounts and of unknown composition. Certain other gems, such as azurite, lapis lazuli, malachite and turquoise, have the beautifying color actually a property of the chemical constituting the gem. But, on the other hand, the vast majority of stones owe their gem interest to the presence of a small amount of this beautifying constituent, quite apart from the main chemical compound composing the mineral background. For instance, if the pure compound which gives the fundamental properties of hardness or luster, or the like, to the sapphire, topaz, emerald or zircon were present as an absolutely chemically pure product, these stones, and many others, as you see, would be colorless, with very little character, and would lose a very large proportion of their value as precious stones. But when there appears, superimposed upon the composition of the mineral, a small amount of these beautifying constituents, we have the wonderful blue of the sapphire or the gorgeous red of the ruby or the soft brown tints of the topaz.

These beautifying constituents occur in relatively small amounts and, because of their influence in changing these minerals otherwise of little value to gems of great value, it is asserted that they create more actual worth than anything else in the world of the same weight. The beautifying constituent of the emerald is 1½ per cent. of chromium, which added to the colorless goshenite makes the emerald, and by so doing changes the almost valueless goshenite into that most valued of all gems—imparting a value of frequently more than $1,000 for each carat of emerald. At this rate the value imparted by the chromium as beautifying constituent figures out to the rate of $150,000,000 per pound of the chromium. Is it any wonder that I call these often rated impurities the beautifying constituents? Actually by making the minerals less perfect they enhance the beauty and increase the value. The imperfect becomes the more valuable! These beautifying constituents, comparatively minute in their percentage yet imparting the magnificent color to most of our gems, may be looked upon as the most interesting and indeed the romantic feature of the structure of these jewels. Our eye all along has seen this sumptuous beauty; may our mind be trained to conceive its cause!

In our study of gems we have found out much about the different ones that are pleasing to us, and we shall arrange these according to their chemical structure in a number of classes, and point out their beautifying constituents when these are known, as shown in the following sections.

Elements

In this group is the leader before all gems—the diamond. It is usually in a pure form, indeed the very purest form of carbon, and its outstanding properties of luster, hardness and fire are conferred upon it by the inherent structure of this form of carbon. Yet, even here the value is enhanced in certain very rare instances by the presence of some beautifying constituent that adds color, as when we have the rare red or other colored diamond. This gives an exceptionally pleasing combination, with color added to the diamond's usual superior qualities of brilliance, hardness and fire.

Oxides

Silica: The common or ordinary sand of our shores falls within the classification of silica. Likewise under this heading are a great many varieties of gems, and indeed the very purest form of silica is our rock crystal, which furnishes such beautifully crystal-clear brilliant beads and ornaments. In this group, in a superlative degree, the beautifying constituents come into play, adding a broad range of color and texture to these stones.

We do not know what all these beautifying constituents are, but we have ascertained that a small amount of ferric iron present in crystal silica furnishes citrine, or, as it is generally called, false topaz, or simply topaz.[2] A little manganese gives the beautiful, soft tints of the rose quartz, and also a little iron probably furnishes the much-prized amethyst. In certain instances, inclusions add the particular beauty to the quartz, such as the opalescent appearance of milky quartz, caused by minute liquid-filled cavities, or the Venus hair stone, wherein the needle-like crystals of

[2] This name should not be used for citrine, but only for the rare real or precious topaz.

rutile or actinolite or even tourmaline lend interest and distinction to this special form of quartz.

There is a variety of quartz which lacks the clear crystalline form of our rock crystals, possessing a fibrous structure. This, in its soft gray tone, is recognized as chalcedony or, when a little ferric oxide comes in, evenly distributed as a beautifying constituent, we have the reddish carnelian; while with agate we have the same basic material, colored unevenly with this same ferric oxide, and as sardonyx we recognize a banded material with red and white layers. When manganese oxide is found in with the chalcedony in a dendritic or tree-like form, we call it moss agate.

Finally, in our silica family, when water occurs as an integral part of the gem, setting up strains and internal irregularities, we possess that most beautiful and most highly prized of all varieties of silica, the opal. If one takes such a stone and looks at it by transmitted light, there is little or no color, but the reflected rays are broken down by interference into the rainbow hues which are the glories of our opals. This same phenomenon also causes the play of color when a thin film of oil floats on water. Depending upon how the internal irregularities of the opal are arranged, we have different varieties of this lovely stone which we call by various names, such as fire opal, black opal or harlequin opal. Because these stresses sometimes exceed the natural bond or coherence of the gem, we lose an occasional fine opal by cracking. Thus does the cause of the breath-taking beauty of the opal sometimes carry also its own fragility! But this should rather lead us to prize more truly such changing and radiant colors.

Corundum: The mineral corundum in composition is aluminum oxide or alumina. A somewhat similar product is manufactured on a large scale out of bauxite or the raw material for aluminum. Corundum occurs crystalline in nature in various forms. When perfectly pure it is the white sapphire. On the other hand, when very impure, mixed with magnetic oxide or iron, we call it the abrasive, emery. When nature adds the impurities, or beautifying constituents, to the white sapphire, with discretion we may say, we get some of our most beautiful jewels. The gorgeous ruby is pure crystalline corundum, or white sapphire, carrying 1 per cent. or 2 per cent. of chromium oxide as the cause of its unusual beauty. The blue sapphire is colored with oxides of titanium and iron. The rare, but very attractive golden, or yellow sapphire owes its color to iron oxide alone, and there are many others of the so-called fancy sapphires which occur in various colors, such as violet, pink and even green.

It is here that the synthetic chemist has exercised his chief skill and knowledge, for he has taken the pure alumina and mixed with it these various beautifying constituents, and then by passing this mixture through the intense heat of the oxyhydrogen flame has made synthetic sapphires and rubies which are duplications of those found in nature. Thus does synthesis confirm analysis. Furthermore, in the controlled operations of a factory, man has made other synthetic gems, such as are not found in nature, wherein the coloring constituent is a small amount of materials, as oxides of uranium or vanadium, which give effects somewhat different from the naturally occurring materials. Man has brought the coloring constituents into the sapphire base which have never happened to come into juxtaposition in nature.

Spinels: When magnesium oxide occurs with aluminum oxide we have spinels. These resemble the corundum gems, sapphire and ruby, except that they are not quite so hard and melt a little lower. On the other hand, they give very gorgeous stones. The ruby of the Black Prince in the crown of England, one of the most famous gems in the world with a recorded history of half a thousand years behind it, is really a ruby spinel. Because of the slightly lower melting point one has been able more easily to synthesize spinels, and we find among our man-made gems many examples of the skilful use of unusual constituents to impart beauty of color to the otherwise clear and white magnesium aluminate or spinel. A fine example of this is the cobalt colored synthetic blue spinel, which has a clearer and deeper coloration than the natural blue spinel.

Chrysoberyl is a combination of beryllium oxide with aluminum oxide, and again the pure mineral is colorless. However, one of the rarest and most beautiful of all gems, the alexandrite, is chrysoberyl with the beautifying constituent believed to be chromium oxide, which causes the change in color characteristic of the alexandrite, showing green by daylight and red by artificial light. When the structure of the chrysoberyl is so arranged in fibers that a beautiful light streak appears across the mineral, we recognize this added beauty as furnishing the cat's eye, or cymophane, a highly prized gem.

Hematite: Common, ordinary iron oxide, source of so much of our steel, does occasionally carry crystals in such hard dense masses, with black metallic luster, that it has been employed for minor jewel use. Unlike the case with our other oxides, the color is due to the inherent nature of the compound, and not to a mixture with any lesser constituent. We speak of this type of coloration as being idiochromatic.

CARBONATES

With copper carbonates, malachite and azurite, the cause of green and blue color is due to the structure of the mineral and is another example of idiochromatic or self-colored gem. In other carbonates there are present beautifying constituents, or a variation in the

physical structure, causing such lovely iridescence as is found in the pearl.

SILICATES

A large proportion of the ordinary rocks that make up the fundamental structure of the globe are silicates. Among some of the specialized silicates occur magnificent jewels, such as the emeralds and aquamarines, jades and zircons, topazes and tourmalines.

Beryl: Pure beryllium aluminum silicate is colorless, and this form is known as the mineral, goshenite; but when beautifying constituents are present we have the green emerald, the green-blue aquamarine, the golden beryl and the pink morganite. The emerald is our scarcest and most valuable gem, a small amount of chromium being considered to be the beautifying constituent that imparts this color so greatly desired. The scarcity of these emeralds can be comprehended when it is recognized that many of the fine emeralds are those that were found when Pizarro conquered Peru, centuries ago, and that even now the same Andean mines are supplying high-priced jewels.

Garnets: These are quite complicated silicates, embracing almost every color but blue. Some varieties of garnet when pure are colorless, as is true of the ordinary pyrope garnets employed in Bohemian jewelry. Presumably here the beautifying constituent is iron oxide.

Jade: A stone that is indeed venerated by the orientals is jade; even the names applied to the different varieties have a romantic sound, such as "mutton-fat" jade or "imperial" jade or "melting-snow-of-camphor" jade. The jades consist of the minerals jadeite and nephrite and are complicated silicates. Quite frequently ferrous iron is the beautifying constituent, imparting the soft green color so highly prized.

Zircons: Pure white zircon is incorrectly called the "mature diamond." It is that gem, next to the diamond, with the highest brilliancy and fire, due to its high index of refraction and high dispersion. But zircons are comparatively soft and should be repolished occasionally. Brown, and particularly blue zircons, are much sought after. The beautifying constituents are not recognized, but iron oxides do play a part in these splendid gems.

Topaz: Most of us think of the topaz as possessing a warm brown color, but this alumino fluosilicate when pure is colorless. It is often pale blue, wine yellow and occasionally pale red. We know very little about the coloring and beautifying constituents of this gem. The coloring matter is comparatively unstable, and pink topazes are frequently made by simply heating. However, alteration does not take place under ordinary conditions of use. Because of such change of color of the topaz we do not believe it is due to the metallic oxides, but to some colloidal constituent.

Tourmalines are borosilicates with beautifying constituents present to furnish a great variety of colors, which may be pink, rose red, green, dark blue or colorless. Sodium and lithium occur in the rose red rubellite, though there may be even here another still unknown constituent that imparts this color. If much iron is present there occurs the black non-gem variety known as schorl.

PHOSPHATES

Turquoise is another gem wherein the color is caused by the copper-bearing nature of the mineral. This color does change somewhat with the ratio of copper-iron, wherein the variance will go from blue, due to copper, to green, where ferric iron is present.

SULFATES

Satin Spar: Crystallized calcium sulfate is quite soft and it must therefore be handled carefully and polished frequently, yet the irregularities in the growth of its fibrous structure imparts that chatoyant luster to this mineral which leads to its use in such semi-precious jewels as beads, and the like, wherein the wear is not very pronounced.

We have traveled from one gem to another, and seen something of their various types of beauty—and the cause of all this! Is there not as much romance and seeming mystery in the flaming colors of an opal—caused by imperfections—yes, cracks in its structure; or in the gorgeous greenness of the emerald, resulting from the presence of but a small amount of chromium; or in the limpid magnificence of a pearl, based here also on irregularities of composition—are not all these as romantic as the conquest by the Normans or the love wanderings of Evangeline or the landing of the Pilgrims?

We now take leave of our jewels—jewels born in travail of heat, fire and stupendous forces—jewels born not in a few hours, but in the processes of the ages—jewels born in the recesses of the earth—jewels revealed only by man delving deep into the secret places of the world or by the natural disintegration of these hidden deposits by the slow action of wind and water, heat and cold.

OBITUARY

CHARLES WILLIAM WOODWORTH

CHARLES WILLIAM WOODWORTH,[1] entomologist, mathematician, physicist, chemist and inventor, was born at Champaign, Illinois, on April 8, 1865, and died at his home in Berkeley, California, on November 19, 1940. He was educated in the public schools of Illinois

[1] E. J. Wickson, *Pacific Rural Press*, 102: 353 (front), portrait, 1921. E. O. Essig, "A History of Entomology," pp. 800–802, portrait, 1931.

and was graduated from the University of Illinois with the B.S. degree in 1885 and took the M.S. degree there in 1886. During the period 1884–1886 he was assistant to S. A. Forbes, and from 1886 to 1888 and from 1900 to 1901 he studied at Harvard University under H. A. Hagen, at that time the leading entomologist of this country. In 1888 he was appointed entomologist and botanist at the Arkansas Agricultural Experiment Station. Due to successive attacks of malaria he left there in 1891 to become assistant in entomology at the University of California where he enjoyed the opportunity of founding and building up the Division of Entomology and of participating in the solution of the multitudinous entomological problems of the Agricultural Experiment Station in a region entirely new to him. Under the leadership of E. W. Hilgard and E. J. Wickson, respective deans and directors, he received much encouragement and help and rose to be assistant professor of entomology in 1891, associate professor in 1904 and professor in 1913. Upon retirement at the age of 65 in 1930 he was made emeritus professor of entomology. Also in the spring of 1900 he was appointed lecturer on comparative anatomy at the Hahnemann Hospital College of San Francisco, and later in 1906 he was a candidate for the presidency of the Mississippi State University. While on sabbatical leave in 1918 he was lecturer at the University of Nanking and honorary professor of entomology at the National Southeastern University at Nanking, China. During this year he also gave public lectures; made a mosquito survey over an area of 38 square miles and effected a practical control of the mosquitoes for the first time in the history of that city; gave courses in sericulture and greatly improved the methods of rearing and handling silkworms; taught summer classes; and organized the Experiment Station for the College of Agriculture and Forestry, which subsequently became a part of the university. He returned to China for a period of three years (1921–1924) and during that time he organized the Kiangsu Provincial Bureau of Entomology; initiated research on the biology and control of agricultural insect pests, the housefly and mosquitoes; and materially aided in the establishment and operation of several small commercial insecticide manufacturing companies of which there was a dearth in China. In the words of the president of the University of Nanking, "He served China in a magnificent way." In this period also he made a trip around the world, one purpose of which was to identify a collection of Chinese insects at the British Museum. This latter effort was prevented by the loss of the specimens through their being carelessly dropped overboard by the ship's crew. Since retiring from the University of California, he had devoted himself to an extremely varied program at home and abroad. From 1930–1932 he was chief entomologist for the California Spray Chemical Company and spent much of his time traveling in South America. He was at Rochester, New York, in 1934–1935 and there gave a series of lectures on optics to certain members of the Bausch and Lomb Optical Company.

Woodworth came to California at the time when there were many new and pressing problems in entomology and a great need for teaching, research and practical demonstrations in control. Single-handed he set out to do what a hundred or more entomologists are trying to accomplish at the present time. His powers of concentration and his industry and productiveness can be attributed to an unusually resourceful mind, a strong and healthy body and a keen interest in his work. He often toiled almost day and night to develop an idea, and he usually communicated his thoughts to others in order to gain a wider viewpoint concerning a problem. During my thirty years' association with him I never saw him angry or heard him utter an unkind word. His habits indicated a sound moral character. He traveled extensively throughout California and the United States and made a trip to Europe in 1901 in addition to the trip around the world and the one to South America I have already noted. Contacts with farmers he maintained by writing letters and answering inquiries and determining insect specimens; publishing circulars, bulletins and reports; addressing farmers' institutes and other meetings; and by farm visits; by training students in entomology; and by cooperative investigations and demonstrations relating to the control of insect pests. He had much to do with the early development of the manufacture and uses of London purple, Paris green, calcium arsenate, acid and basic lead arsenate, calcium arsenite, zinc arsenite, lime-sulfur, petroleum oil emulsions and sodium and potassium cyanide fumigation. To protect the farmers against losses due to adulteration of Paris green he proposed and drafted the first California Insecticide Law in 1906, was largely instrumental in securing its passage in 1911 and administered the law until July 1, 1923. Entomological campaigns which he conducted in California concerned the codling moth, the peach twig-borer, citrus insects, grasshoppers, citrus white fly eradication, and the proper allowances for tent leakage in HCN fumigation of citrus trees.

He was much interested in theology and belonged to the Baptist Church; in prohibition and was a delegate to one of the California state conventions; in chess, which he studied mathematically and analyzed 30,000 games; shorthand, in which he perfected an extensive new system; mathematics, concerning which he wrote on logarithms and anti-logarithms and published a booklet on "Five-place Arc Sines and Cosines for Machine Calculation Interpolating to Eight"; physics, in which optics interested him for many years and

concerning which he published "Contribution to the Optics of the Microscope" in 1919 and "Microscope Theory" in 1924; and chemistry, in which he invented and patented a new process for the distillation of petroleum oils at low temperatures.

His publications in entomology are very extensive and included nearly every field; systematic and economic entomology, anatomy, physiology, toxicology, ecology, apiculture and sericulture. A few of his most outstanding works are: "A List of the Insects of California" (1903), "The Wing Veins of Insects" (1906), "Guide to California Insects" (1913) and "School of Fumigation" (1915). He was the first editor and first contributor to the University of California Publications in Entomology.

He was married to Leanora Stern in 1889, who bore him three sons, Lawrence, Harold Evans and Charles Edward, and a daughter Elizabeth, all of whom survive him. Following the death of his first wife, he was married to Bernice Christopher in 1926. The latter died in 1930.

E. O. ESSIG

UNIVERSITY OF CALIFORNIA

RECENT DEATHS

DR. THOMAS RUSSELL WILKINS, professor of physics at the University of Rochester, died suddenly on December 10 at the age of forty-nine years.

DR. GLADWYN KINGSLEY NOBLE, curator of the departments of herpetology and experimental biology of the American Museum of Natural History, with which he had been connected since 1919, died on December 9 at the age of forty-six years.

DR. F. W. EDWARDS, since 1937 deputy keeper of entomology at the British Museum (Natural History), died on November 15 at the age of fifty-one years.

DR. HEINRICH KAYSER, emeritus professor of physics of the University of Bonn, known for his work in spectroscopy, died on October 14 at the age of eighty-seven years.

Nature reports the death of M. Charles Nordman, since 1920 director of the Paris Observatory, on November 15 at the age of fifty-nine years; of Professor Hans Rosenberg, an authority on astronomical photometry, formerly director of the observatory at Istanbul, aged sixty-one years.

SCIENTIFIC EVENTS

THE WAR AND THE BRITISH FAUNA[1]

IT is probably still too early to judge the effects of the war upon British wild life, for it was not until the second or third years of the war of 1914–18, when the calling-up of older men had more extensively depleted the game-keeping profession, that the great increase in so-called "vermin," including rarer species like the wild cat and polecat, became of national concern; nevertheless, the present war has speeded up a great deal of this disturbance of wild life by the greater activity at home. The most noticeable effects have been an extension of the range of normally persecuted species like the carrionerow, fox, otter, kestrel, little owl and sparrowhawk and this may be followed by a slower extension of species like the badger and raven. The use of sand-dunes and lonely islands in the coastal defenses and of rural parks for training the army has considerably disturbed the nesting haunts or "sanctuaries" of uncommon species, particularly birds, more so than the building of factories in rural areas, and this may have a permanent effect in further reducing the nesting population of terns, waterfowls and waders.

On the other hand, the breaking up of estates and game preservation is furthering the extension of the little owl and the grey squirrel in the north of England. As in 1914–18, the rumor has gained popularity that warfare on the Continent has sent rarer Continental birds to nest in England, notably the avocet in Essex, but it is unlikely that the campaign abroad had any effect upon the British avi-fauna. Pollution of rivers has again arisen, notably on the Severn, Bristol Avon, and the Derbyshire Derwent, with considerable loss of fish life. It yet remains to be seen if the rosebay willow-herb will emulate the story of the London rocket in spreading over ruined buildings in London and other cities; that the poppy will recolonize the Flanders area in its former abundance is very likely, for the destruction of buildings has again made the soil highly calcareous.

[1] From *Nature*.

THE HERBARIUM OF THE NEW YORK BOTANICAL GARDEN

THE herbarium of the New York Botanical Garden, into which the two millionth specimen was incorporated at a special ceremony on the afternoon of December 11, is the largest herbarium in the United States being operated under a single head. The ceremony, during which Joseph R. Swan, president of the Board of Managers of the garden, placed the two millionth specimen in its niche in the herbarium, was preceded by a program beginning at 3:30 P.M. in the Museum Building, and was followed at 4:30 by tea served in the new Members' Room.

In his opening remarks, Dr. William J. Robbins, director, briefly described the research work being done at the New York Botanical Garden through the aid of the herbarium. In addition to many thousands

of specimens identified every year as a service to the public, this work included special studies of many families of plants.

Other speakers were: Dr. H. A. Gleason, assistant director and head curator, on "Important Publications from the Garden Herbarium"; Dr. H. N. Moldenke, associate curator, on "Important Collections in the Herbarium"; E. J. Alexander, assistant curator, on the "Relation of the Herbarium to Horticultural Progress"; Dr. W. H. Camp, assistant curator, on "The Herbarium in Scientific Research," and Dr. J. H. Barnhart, on "The History of the Garden Herbarium." In his address Dr. Barnhart called attention to the circumstance that several parts of the herbarium had received special names in commemoration of former members of the staff. The first to be so honored was Professor L. N. Underwood, who died in January, 1907. A year later the entire fern collection was officially designated the "Underwood Fern Herbarium," and a bronze tablet was installed recording the fact. In 1934, Mrs. Britton's work was commemorated in the naming of the moss collection the "Elizabeth Gertrude Britton Moss Herbarium," and in the following year the general herbarium was designated the "Britton Herbarium," in memory of the first director of the garden.

While slightly exceeded by the United States National Herbarium in Washington in its specimens of flowering plants, the herbarium of the New York Botanical Garden ranks first in the country in plants of certain regions; for example, the southeastern states, the West Indies and Bolivia, and in the flora of Asia. It also stands first in mosses and in myxomycetes (a low order of plants somewhat akin to the fungi), and ranks among the first in its collections of algae and fungi.

Altogether, the herbarium contains 1,388,833 specimens of flowering plants and ferns; 177,000 mosses; 61,400 liverworts; 87,500 algae, and nearly 305,000 fungi, including lichens, making a total to date of 2,019,000 specimens. The two millionth to be accessioned was a specimen of a rare clematis collected in Kentucky last summer by Dr. Gleason, who with John Dwyer, a graduate student from Fordham, was making an extensive collecting trip through the eastern and central states.

Special studies being carried out at the garden by members of the staff are:

Dr. H. A. Gleason, head curator, is working in the Melastomes, an American group of nearly 4,000 species, a number of which are in greenhouse cultivation.

Dr. H. N. Moldenke, associate curator, is studying the Verbena and Black Mangrove families throughout the world, and is also doing research on the plants of the Bible, the flora of the Watchung Mountains of New Jersey, and on certain arrow poisons used in South America.

Dr. W. H. Camp, assistant curator, is working on the Blueberries and their relatives from the viewpoint of a botanist, and is also at present investigating the beeches, making special studies of the flowers and of the remnants of these trees from past geological ages.

E. J. Alexander, assistant curator, works on the flora of the Southern States, on the Cacti and other types of succulent plants—especially those which the Garden has on display in the conservatories. He is responsible for the correct naming of all the plants cultivated at the New York Botanical Garden.

B. A. Krukoff, honorary curator of economic plants, devotes his energies to plants of medicinal importance.

A number of graduate and fellowship students are also working on special plant problems at the Botanical Garden.

FIFTIETH ANNIVERSARY OF THE INSTITUTE OF EXPERIMENTAL MEDICINE IN LENINGRAD

DR. W. N. BOLDYREFF, now of Tucson, Arizona, writes to SCIENCE calling attention to the fiftieth anniversary of the Institute of Experimental Medicine which was founded at St. Petersburg by Prince A. P. Oldenburg in December, 1890, with the cooperation and advice of Louis Pasteur.

Dr. Boldyreff worked at the institute for many years. From the first young scientific men of promise were made directors of the separate laboratories. The chiefs of departments included I. P. Pavlov, physiology; M. V. Nezki (a Pole), biochemistry; S. N. Vinogradski (now vice-director of Pasteur Institute at Paris), microbiology; N. V. Uskov, pathological anatomy; S. M. Loukianov, pathology; H. J. Gelman, veterinary medicine; V. A. Kraiushkin (of the Pasteur vaccination against hydrophobia), and N. C. Shulz, practical bacteriology. Dr. M. V. Nezki had been a professor in the University of Bern, Switzerland, and Dr. S. N. Vinogradski was an associate of Louis Pasteur and had discovered the microbe acidifying ammoniac in the ground.

The institution worked not only for purely scientific purposes, but also for the application of new discoveries to the needs of every-day life such as the fight against different infectious diseases, the invention of better methods of disinfection, the elaboration of new drugs and methods of treatment of disease, etc. It was fully equipped. Much money was given for experimental work and for the salaries of investigators and other employees. The director of the institute (the first director was Dr. E. F. Sperk, the specialist in syphilology) and all assistants had furnished quarters in the building, situated in a beautiful park on the edge of the city. There was established also a cheap but excellent restaurant for employees.

The institute was attended by many young doctors and other scientific workers. Papers were published in its own journal, *Archives des Sciences Biologiques* both in Russian and French, and in the best foreign journals.

Here Pavlov did all his scientific work and completed classical experiments on digestion and conditioned reflexes. Many well-known scientific men graduated from the institution and many papers were published, some of them devoted to the discoveries made in the institute. A few of those who participated in its foundation are still living. Among these are Dr. S. N. Vinogradski (Paris) and Dr. V. G. Ushakov (Leningrad), who was at that time and later secretary of the council of the institute.

CONFERENCE IN HONOR OF LETA S. HOLLINGWORTH

A CONFERENCE on Education for the Gifted in honor of the late Professor Leta S. Hollingworth was held at Teachers College, Columbia University, on December 13 and 14. Dr. William F. Russell, dean of Teachers College, was honorary chairman of the conference and Dr. Herbert B. Bruner, professor of education, was chairman. The introduction to the printed program says: "This Conference on Education for the Gifted is held in honor of Leta S. Hollingworth, professor of education in Teachers College, whose untimely death last year brought to a close a brilliant career. Our discussions here are designed to promote increased activity in the discovery and education of the gifted—the task to which she so earnestly devoted herself and which she considered of paramount importance in our national life."

Speakers and their subjects at the opening meeting, over which Professor Lyman Bryson presided, included Dr. Nicholas Murray Butler, president of Columbia University, whose address was entitled "The Basic Problem," and Dean William F. Russell, who spoke on "The Importance of Social Capillarity." They were followed by a presentation of "Major Problems Regarding the Gifted"—The Place of the Gifted in Modern Life. In this discussion Lammot du Pont spoke from the viewpoint of industry; Spencer Miller, Jr., from the viewpoint of labor, and Bishop Francis J. McConnell, from the viewpoint of the ministry. Other speakers were Robert L. Thorndike, associate professor of education; Herbert B. Bruner, professor of education, and David E. Weglein, superintendent of schools, Baltimore, Md.

Friday afternoon was devoted to seminars, of which there were thirteen as follows: Who is the Gifted Child?; What Special Problems Are Encountered by the School Administrator in Providing for the Education of the Gifted and How May These Problems Be Solved?; What Is the Place of the Gifted in Modern Life?; Gifted Children; their Educational Needs; Education of Gifted Pupils in Secondary Schools; How Can We Best Educate Teachers for Work with Gifted Children?; What Are the Physical and Mental Health Problems of the Gifted and How Can They Best Be Met?; Home Guidance of the Gifted Child; How Can We Release the Creative Energies and Develop the Creative Capacities of the Talented Gifted Child?; Research Problems in the Study of Gifted Children; How Do the Intellectually Gifted Evaluate Their Own Educational Experiences?; What Provision Should Be Made for the Education of Gifted Persons at the College Level?; How Should a School Be Organized to Provide for the Most Effective Education of the Gifted?

At the evening session on Friday, presided over by Dr. Arthur I. Gates, professor of education, Professor Rudolph Pintner gave an address on "Superior Ability," and Dr. Edward L. Thorndike, professor emeritus, spoke on "Gifted Children in Cities and Towns."

There was a display of books and miscellaneous work of gifted children from various schools and of testing materials and cumulative records, and demonstrations of tests on children of superior intelligence and a presentation of motion pictures taken by Dr. Hollingworth, showing the work in the Speyer School.

THE JOSIAH WILLARD GIBBS LECTURES OF THE AMERICAN MATHEMATICAL SOCIETY

AT the meeting of the American Mathematical Society held at Vassar College in September, 1923, a resolution was adopted sanctioning the establishment of an honorary lectureship to be known as the Josiah Willard Gibbs Lectureship. The first lecture given under these auspices was on February 29, 1924, by Professor M. I. Pupin, of Columbia University, on the subject, "Coordination." Professor Veblen was then president of the society, and the purpose of the lectureship can perhaps best be summed up by quoting from his remarks in introducing the speaker.

In instituting the Willard Gibbs Lectures, the American Mathematical Society has recognized the dual character of mathematics. On the one hand, mathematics is one of the essential emanations of the human spirit,—a thing to be valued in and for itself, like art or poetry. Gibbs made notable contributions to this side of mathematics in his work on vector analysis and multiple algebras.

On the other hand, mathematics is the handmaiden and helper of the other sciences, both in their most abstract generalizations and in their most concrete applications to industry. In this field Gibbs may be justly described as transcendental,—even if we think only of his work in thermodynamics. His paper "On the Equilibrium of Heterogeneous Substances" is one of the foundation stones of physical chemistry.

It is hoped that the Willard Gibbs Lectures will remind

the mathematicians of something that we fear they sometimes forget,—the existence of an outside world. It is equally hoped that they will remind the outside world that mathematics is a going concern,—not a pedantic exercise for the torment of school boys, but a living organism growing larger and stronger each year.

Since this first lecture by Professor Pupin, the following scientific men have accepted the invitation of the society to speak under the auspices of this lectureship:

Robert Henderson: Life Insurance as a Social Service and as a Mathematical Problem.
James Pierpont: Some Modern Views of Space.
H. B. Williams: Mathematics and the Biological Sciences.
E. W. Brown: Resonance in the Solar System.
G. H. Hardy: An Introduction to the Theory of Numbers.
Irving Fisher: The Application of Mathematics to the Social Sciences.
E. B. Wilson: Reminiscences of Gibbs as a Student and Colleague.
P. W. Bridgman: Statistical Mechanics and the Second Law of Thermodynamics.
R. C. Tolman: Thermodynamics and Relativity.
Albert Einstein: An Elementary Proof Concerning the Equivalence of Mass and Energy.
Vannevar Bush: Instrumental Analysis.
H. N. Russell: Model Stars.
C. A. Kraus: The Present Status of the Theory of Electrolytes.
Theodore von Kármán: The Engineer Grappling with Non-linear Problems.

The next lecture will be given by Professor Sewall Wright, of the department of biology of the University of Chicago, at the time of the summer meeting of the society and the Mathematical Association of America to be held at the University of Chicago next September.

SCIENTIFIC NOTES AND NEWS

AT the annual dinner of the Geological Society of America to be held in Austin, Texas, on December 27, the Penrose Medal will be presented to Dr. N. H. Darton, consulting geologist, who from 1886 until his retirement in 1936 was geologist of the U. S. Geological Survey.

DR. T. HARPER GOODSPEED, professor of botany and director of the botanical gardens of the University of California, has been elected a foreign correspondent of the Argentine Scientific Society.

G. WALTER DITTMAR, professor emeritus of the College of Dentistry of the University of Illinois, will be the guest of honor at a banquet to be held at the Lake Shore Club of Chicago on February 15. Dr. Dittmar is a past president of the American Dental Association. He retired from active teaching last September.

THE honorary fellowship of the Canadian Public Health Association has been conferred on Dr. E. W. Montgomery, emeritus professor of medicine at the University of Manitoba, formerly Minister of Health and Public Welfare of the Province of Manitoba, and on Dr. J. M. Ulrich, Minister of Public Health and Provincial Secretary of the Province of Saskatchewan.

DR. RICHARD S. WEISS, professor of clinical dermatology of the School of Medicine of Washington University, St. Louis, was elected at the Chicago meeting president of the American Academy of Dermatology and Syphilology.

AT the thirty-sixth annual meeting of the American Society of Tropical Medicine, which was held in Louisville, Ky., from November 12 to 15, in conjunction with the annual meeting of the Southern Medical Association, the following officers were elected: *President,* Thomas T. Mackie, New York City; *President-elect,* Ernest Carroll Faust, New Orleans, Louisiana; *Vice-president,* Fred L. Soper, Rio de Janeiro, Brazil; *Secretary-Treasurer* for three years, E. Harold Hinman, Wilson Dam, Ala.; *Editor* for three years, Colonel Charles F. Craig, San Antonio, Texas; *Councilors* for four years, R. E. Dyer, Washington, D. C., and T. J. LeBlanc, Cincinnati; *Member of the editorial board* for five years, John F. Kessel, Los Angeles, Calif.

R. E. ZIMMERMAN, vice-president of the United States Steel Corporation, was elected president of the American Standards Association at the annual luncheon meeting held on December 11 at the Hotel Astor, New York City. Mr. Zimmerman has served as vice-president of the association since 1938, and has been a member of the Board of Directors since 1937, when he was nominated for membership by the American Iron and Steel Institute. He will succeed Edmund A. Prentis, of the firm of Spencer, White and Prentis, who has served as president of the association for the past two years. R. P. Anderson, of the American Petroleum Institute, was reelected chairman of the council, which is in charge of the technical work of the association.

DR. JAMES L. BRAKEFIELD, professor of biology and head of the department at Howard College, will complete his second term as president of the Alabama Tuberculosis Association at the annual meeting to be held on January 23. During Dr. Brakefield's administration local county and municipal organizations for the study and control of tuberculosis have been formed

in more than sixty of the sixty-seven counties of Alabama.

DR. ERIC T. B. GROSS, formerly lecturer in the School of Electrical Engineering of the Institute of Technology in Vienna and head of the engineering division of the Central Station Department of the Union Electric and Manufacturing Company in Vienna, has been appointed Westinghouse research associate in the School of Electrical Engineering at Cornell University.

DR. W. L. H. DUCKWORTH, master of Jesus College, Cambridge, has retired from the readership in human anatomy after twenty years in that office; Dr. G. S. Graham-Smith has retired from the readership in preventive medicine.

DR. JOHN B. BAKER, for the past six years assistant professor of mechanical engineering at the Drexel Institute of Technology, Philadelphia, has a year's leave of absence to become instructor for the Engineer Organized Reserves. His headquarters will be at the First Military Area, Customs House, Philadelphia, where he will be in charge of the training, assignments, transfer and procurement of engineer reserve officers.

THE Rockefeller Foundation has made a grant to aid a five-year program of research in the genetics of plant growth under the direction of Dr. Donald F. Jones, geneticist at the Agricultural Experiment Station at New Haven.

THE Committee on Scientific Research of the American Medical Association has awarded to Dr. Arthur C. Allen, of the Mount Sinai Hospital, New York City, a grant for the study of the effect of certain drugs on the vegetations of experimental bacterial endocarditis.

THE London *Times* reports that Sir George Chrystal, secretary of the British Ministry of Health, is retiring on reaching the age limit. Sir John Maude, deputy-secretary, has been appointed to succeed him, and A. N. Rucker has been made deputy-secretary. Sir Arthur MacNalty, chief medical officer of the Ministry of Health and of the Board of Education, also is retiring on reaching the age limit. The Minister of Health and the president of the Board of Education have respectively appointed Sir Wilson Jameson to be chief medical officer of the Ministry of the board. Sir Wilson Jameson is relinquishing the post of medical officer to the Secretary of State for the Colonies. He is also relinquishing the post of dean of the London School of Hygiene and Tropical Medicine and professor of public health in the University of London.

THE British Ministry of Food announces that the Flour (Vitaminisation) Advisory Committee, which was recently appointed, will have the assistance in its official capacities of Professor D. S. M. Watson, of the Scientific Sub-Committee of the Food Policy Committee of the Cabinet; of P. N. R. Butcher, of the Ministry of Health, and of the following officers of the Ministry of Food: Sir Norman Vernon, director of flour milling; Professor J. C. Drummond, scientific adviser; Dr. T. Moran, deputy scientific adviser, and Mr. J. H. Pillman, manager for imported flour.

DR. WALTER L. BIERRING, president, and Dr. J. J. Moore, secretary, of the Alpha Omega Alpha honorary medical fraternity, participated in the installation of a chapter of this fraternity at the Medical College of Virginia on December 4.

DR. NOEL PAUL HUDSON, professor of bacteriology at the Ohio State University College of Medicine, has a year's leave of absence to join the health commission of the Rockefeller Foundation working in France. With other members of the commission Dr. Hudson left late in October. He had previously served with the International Health Division of the Rockefeller Foundation.

DR. PEYTON ROUS, a member of the Rockefeller Institute for Medical Research, on December 6 and 9 delivered the William Henry Welch Lectures at the Blumenthal Auditorium of the Mount Sinai Hospital of New York.

DR. SELIG HECHT, professor of biophysics at Columbia University, lectured on December 6 at a meeting of the Rochester Chapter of Sigma Xi at the University of Rochester on "The Chemistry of Vision."

DR. FIRMAN E. BEAR, head of the department of soils and crops of Rutgers University, spoke at the New York Botanical Garden on December 10 on "Plants and the Course of Civilization."

JAMES STOKLEY, editor in astronomy for Science Service, lectured at the Cosmos Club, Washington, D. C., on December 9. The title of his lecture was "Roaming the Heavens."

THE Huxley Memorial Lecture of the Royal Anthropological Institute, London, was delivered by H. J. E. Peake on November 26. He spoke on "The Study of Prehistoric Times."

AT the December meeting of the American Academy of Arts and Sciences, three papers were presented from the Harvard Astronomical Observatory. Fletcher G. Watson spoke on "The Approaching Comet"; James G. Baker on "Trends in Astronomical Optics," and Donald H. Menzel on "Motions in the Solar Atmosphere," showing moving pictures of the solar prominences as photographed on the Pic du Midi by Dr. Bernard Lyot, of Paris.

AT the annual meeting of the Geological Society of America, to be held at Austin, Texas, on December 26,

27 and 28, the address of the retiring president, Dr. Eliot Blackwelder, professor and head of the department of geology at Stanford University, will be given on the evening of December 26, the title being "Science and Human Prospects." Meeting with the Geological Society of America are the Paleontological Society and the Mineralogical Society of America. The address of the retiring president of the Paleontological Society will be given on the morning of December 26, by Dr. Carl O. Dunbar, professor of paleontology and stratigraphy and curator of the Peabody Museum of Yale University, the title of his address being "The Permian Faunas: A study in Facies." The address of the retiring president of the Mineralogical Society of America by Dr. W. F. Foshag, curator of the U. S. National Museum, will be given on the morning of December 27 on "Problems in the Study of Meteorites."

THE Academy Conference of the American Association for the Advancement of Science will meet at the Bellevue-Stratford Hotel, Philadelphia, at 3 P.M. on December 27. The conference is composed of (a) the representatives of the affiliated academies of science (one from each academy) in the Council of the Association and (b) the members of the Executive Committee. The Academy Conference welcomes the attendance of those interested in the relations between the academies and the association. The program will consist of two principal papers which will be followed by informal discussion: "Methods of Bringing the Academy into Closer Relationships with Other Organizations," by Dr. P. D. Strausbaugh, West Virginia Academy of Science, and "Long Range Planning for the State Academies of Science," by Dr. W. F. Rudd, Virginia Academy of Science. The conference will be followed at 6 P.M. by the annual academy dinner to the members of the conference.

THE council of Scientific Societies of Western New York held its first annual scientific symposium on November 23. A large number of technical papers were presented at the afternoon sessions, and in the evening Dr. C. J. Phillips, of the Corning Glass Company, gave a lecture with demonstrations entitled "Modern Miracles in Glass." The purpose of the council is stated to be "To afford scientists in Western New York an opportunity to meet one another, to publicly present the results of their original research and to permanently record these results through publication." Officers of the council are *President,* Irving G. Reimann; *First Vice-president,* A. H. Bennett; *Second Vice-president,* Oscar W. Richards; *Secretary-treasurer,* Harold D. Mitchell. Member organizations are the Amateur Telescope Makers and Observers; the Aquarium, Botanical, Conchological, Geological, Microscopical and Mycological and Bryological Sections of the Buffalo Society of Natural Sciences; the Buffalo Ornithological Society; the Buffalo Section of the American Association of Civil Engineers; the Buffalo Zoo; Canisius College Chemistry, Mendel, Strohaver Science, High-school Science, Roosevelt Field, Allegany Field and Trail, and Science Museum Photographic Clubs; the Mathieson Alkali Works, Inc., Niagara Falls, N. Y.; the Nature Sanctuary Society of Western New York; Pratt and Lambert, Inc., and the Spencer Lens Company.

THE Plant Hormone Laboratory at Connecticut College, New London, will be open from June 23 to August 16, 1941, to adequately prepared graduate students and others wishing to carry on plant hormone research. Special arrangements may be made for shorter periods of investigation. The summer program will consist of laboratory research and seminars. Dr. G. S. Avery, Jr., Dr. J. Berger, biochemist, and other members of the staff will be available as consultants. Board and lodging may be obtained at the College Inn, located nearby. Several fellowships of $100 to $150 each are available, and investigators holding these fellowships will not be required to pay the $15 laboratory fee. Application blanks and further information may be obtained by addressing Professor George S. Avery, Jr., of the department of botany. Wherever possible a preliminary plan for the proposed summer's work should be submitted.

THE Donald R. Dickey Collection and Library of Vertebrate Zoology, valued at more than $100,000, have been given by Mrs. Florence V. V. Dickey, of Ojai, Calif., to the University of California at Los Angeles. The collection contains more than 50,000 specimens of birds and mammals, a library of approximately 10,000 volumes, a small bird egg collection, a photographic collection and miscellaneous items.

DISCUSSION

THE SLEEP OF CANARIES

THESE canaries live uncaged in the laboratory, range in age from six months to nineteen years, and I have considerable opportunity to watch their sleep. Some sleep night after night on the same spot. This spot may be very precise. A blind male during a year and a half roosted seventeen inches from the end of a cabinet, to reach which he had to fly through a fairly encumbered 20 × 20 room, and accomplished this usually without mishap. He would not land exactly on the spot, but often surprisingly near, then carefully edge toward it, seem restless till he had arrived. When such a spot has been held a long time, in the instance of one bird for seven years, usurpers promptly

are driven off, and you have the feeling that "right" weights the contest, so that a larger bird may appear not to have the "courage" of its full strength. The most remarkable example of insistence on a place began with a female who all her life occupied the transom rod over the laboratory door, had that rod taken by her mate on the night of her death, and though the rod has since been occupied by three birds, the occupant each time was of the same blood line. There is, on the contrary, the rarer individual who changes place as the season changes. An elderly female in the spring of the year sleeps on a high perch where most of the birds sleep, in early summer sleeps in the path of a draft from the door, on the hottest summer nights sleeps directly in an open screened window, in autumn moves back to the high perch, and with the coming of winter chooses a branch of a dead tree that stands close by the laboratory radiator.

The mating season here is roughly from February to June. During it the birds are apt to go straight from their activity to their roosts, but the rest of the year, especially on hot days, there will be one or more preliminary gatherings that include sometimes every bird. A gathering may last as long as twenty minutes. The birds stand near together, one preens its feathers, one pecks, one pipes, several may fight, there may be some changing of places, or two may let their bills just touch and hold their bodies as quiet as statues. Blood relations are apt to keep close—the crested, the cinnamon, the striped, the white. Between gatherings there may be eating. What breaks up a gathering is usually some small disturbance that excites one bird to fly, the others following, all presently grouped in a new place. Where and in what number they gathered you can tell afterward by the solid drippings, like milestones.

The birds sleep in one of four general positions. In the first position, either the right or the left leg is drawn up, usually the same leg night after night, the bill and face tucked under the blanket of feathers at the top of the wing. I have known a winter night when every bird slept so. In the second position, the head is not turned round, merely drawn in midway between the two wings, so that the bird looks hunchbacked, never many birds sleeping in that position, and it is more apt to occur where the perch is low and when there is restlessness in the environment. In the third position, and this is strangest, the neck is freely extended and so relaxed that the weight of the head drops it, either repeatedly like a dozing man's in a streetcar, or slowly till the bill rests on the perch, or sinks even lower, both feet then down—this an infrequent position except on hot nights when it may be more comfortable to have the head and neck uncovered, or in old and frail birds who may sleep that way because it takes strength to twist around the heavy head and tuck it under. In the fourth position the bird sleeps resting on its abdomen, the breathing then heaving the body, the position usually meaning bad heart or bad feet.

The act of falling asleep occurs in one of two ways. In the first the bird turns its head, closes its eyes, immediately or after a brief delay tucks its face and bill under the feathers. In the second it holds the head and body utterly still, the eyes wide open, the left fixed apparently on one point in space, the right on another, staring, till abruptly the eyes close and the bird falls asleep, or till the bird rouses, shakes itself and tucks under its head. The staring is noteworthy. It may last a long time. I have seen as many as six birds at various angles, close together, the whole group not by the slightest change the group shape in more than an hour, like an exemplary congregation in a church. An occasional bird apparently sleeps with its eyes open, for I have repeatedly moved my finger the whole way up to one and it did not start off.

Sleep is no more an undisturbed process with canaries than with us. There are light sleepers, heavy sleepers, one who never stirs, several who fall off their perches, one who falls off every night—resumes its sleep right on the spot where it fell. Often a bird wakes just enough to defecate. A certain big Norwich slept straight through the Toscanini concerts coming over the radio on Saturday nights, and in the mating season the tired females also slept through the concerts, but, except for these, everywhere in the nearly dark heights of the laboratory you saw the wide-awake listening heads. The birds sleep commonly with their backs to where the morning light will enter. Most are roused by a flash lamp even when their heads are tucked in. The way an individual may move in its sleep, or the way it may occasionally "mutter" in the middle of the night, suggests that its tiny brain, like ours, may be working when it should be at rest.

GUSTAV ECKSTEIN

UNIVERSITY OF CINCINNATI

TWO FACTORS OF POSSIBLE IMPORTANCE IN RELATION TO THE ETIOLOGY AND TREATMENT OF DENTAL CARIES AND OTHER DENTAL DISEASES

IT has long been known that some of the bacteria which grow on tooth surfaces have the power to ferment carbohydrates to acids which decalcify teeth and thus cause dental caries, or tooth decay.[1] A rapid fall in the pH of bacterial "Plaques" growing on tooth surfaces to as low as 4.1 has been found to occur follow-

[1] W. D. Miller, "Microorganisms of the Human Mouth." Philadelphia. S. S. White Dental Manufacturing Company, 1890.

ing the ingestion of certain carbohydrates.[2] However, the pH of these "plaques" was found to rise to normal (6.0 to 7.0) within 20 to 60 minutes. Previously, the saliva has been thought to neutralize the acid "plaques" on tooth surfaces by virtue of the buffers it contains when secreted from the salivary glands.

Now, however, it has been discovered that in addition to the secreted buffers, the urea in saliva is converted to ammonium carbonate, locally on the tooth surface by the action of certain urease-containing bacteria (such as staphylococcus albus and aureus) which grow on the tooth surface in the bacterial "plaque." This ammonium carbonate neutralizes some of the acids which might otherwise produce caries activity. The urease is present in the bacteria as an endo-enzyme, and is not dissolved in the saliva. Some mouth bacteria, such as certain strains of lactobacilli, have been found to contain no appreciable urease; thus these bacteria not only increase caries activity by the fermentation of carbohydrates to lactic acid, but they also fail to retard caries activity by the conversion of urea to ammonium carbonate.

The pH of bacterial material on tooth surfaces and in cavities has been found to rise as high as 8.5 following rinsing the mouth with a carbamide (synthetic urea) solution. Calcium phosphate tends to be deposited on the tooth from the saliva instead of being dissolved from the tooth at this pH (8.5). Solutions of carbamide, used in conjunction with a tooth brush, have been found to be effective in cleaning teeth, and clinical observations have indicated that the treatment may be of value in some cases of gingivitis and pyorrhea.

Long-term studies of patients with caries and other dental diseases are now being conducted (1) using compounds containing carbamide as a dentifrice or mouth wash; (2) by inoculating the mouth with nonpathogenic urease-containing bacteria; and (3) by a combination of the two agents. These studies promise to shed new light on the causation and prevention of caries and to furnish a new treatment for gingival and periodontal diseases.

ROBERT M. STEPHAN

COLLEGE OF DENTISTRY,
UNIVERSITY OF ILLINOIS

SIGNIFICANCE OF DISSEMINATED METALLIC SULPHIDES IN SEDIMENTARY ROCKS

IN a recent issue of SCIENCE (September 20, 1940) Karl Ver Steeg refers to the presence of small amounts of sphalerite and galena in Mississippian and Pennsylvanian strata of Ohio and suggests that "these occurrences may have some value to students interested in the theories of the origin of sphalerite and galena ores such as those of the upper Mississippi Valley."

In an article entitled "The Geodes of the Keokuk Beds," published in 1916,[1] the writer pointed out the existence of sphalerite, chalcopyrite and even of millerite (NiS) in geodes at certain stratigraphic horizons of Mississippian age in southeastern Iowa and adjacent areas in Illinois and Missouri. The text contains the statement that the occurrences "promise to throw some light upon the origin of more important deposits of these minerals in sedimentary rocks showing no signs of igneous influence."

This note is not intended to detract from Ver Steeg's contribution but rather to supplement his remarks and to call attention again to the possible significance of such information in connection with the problem of origin of the Mississippi Valley lead and zinc ores.

F. M. VAN TUYL

COLORADO SCHOOL OF MINES

VITAMIN STUDY AT THE UNIVERSITY OF TEXAS

THROUGH the generosity of the Clayton Foundation of Houston, we have recently been able to expand our research program under the designation of the Biochemical Institute. Work already under way is being supported by the Rockefeller Foundation and the University of Texas.

Members of our research staff have pioneered in the publication of microbiological methods for the determination of riboflavin, pantothenic acid and biotin (vitamin H). Alternate methods for these and similar assay methods for other vitamins have already been devised or are in process of development.

In the expanded program it is planned, in addition to continuing investigations in progress, to apply these methods to the study and assay of animal tissues of numerous types, including embryonic tissues and tumors. The relationship of these results to the problems of metabolism will doubtless be complicated, and we do not believe anything short of a thorough study can yield results which are significant and capable of interpretation. We are fortunate in being in a position to carry out such an extended study.

Recently added members of the full-time staff include Dr. Alfred Taylor, research biologist; Dr. Maxwell A. Pollack, research chemist; Misses Ernestine Quarles, Margaret Jane Hofer and Juanita Thacker, technical assistants. Additional appointments will be made as the work progresses.

ROGER J. WILLIAMS

UNIVERSITY OF TEXAS

THE QUININE INDUSTRY

SINCE the invasion of Holland on May 10, there have been persistent rumors of Nazi attempts to inter-

[1] *Am. Jour. Sci.*, (4) 42: 34–42, 1916.

[2] Robert M. Stephan, *Jour. Am. Dental Asn.*, Vol. 27, pp. 718–723, May, 1940.

fere with the Dutch quinine industry. The actual facts appear to warrant the following statement.

Heretofore Amsterdam has been the headquarters of an industry which has assured the supply of this world-wide remedy for malaria. By royal decree the management of this quinine industry was transferred to Bandoeng, Java, on May 14, 1940.

We have been warned, although the warning was scarcely necessary, to have no communication with our former associates in Amsterdam for fear such correspondence might be diverted to Nazi ends.

Java is now the center of the world's quinine industry, where ample production is assured of both cinchona bark and manufactured quinine. The latter is produced at the Bandoengsche Kininefabriek, the largest quinine factory in existence. There is thus no danger of a quinine shortage anywhere in the world.

The quinine industry, now centralized in the Netherlands East Indies, is completely Dutch and completely determined that Holland's plight shall not be turned to Nazi advantage. That attitude also actuates those connected either with the sale of Dutch quinine here or with the research and educational program of that industry.

NORMAN TAYLOR,
Director

CINCHONA PRODUCTS INSTITUTE, INC.,
NEW YORK, N. Y.

SCIENTIFIC BOOKS

REGIONAL PHYSIOGRAPHY

The Physiographic Provinces of North America. By WALLACE W. ATWOOD. xvi + 536 pp. 281 figures with large-scale map of the land forms of the United States. Boston: Ginn and Company. 1940. $4.80.

THE National Geographic Society in 1895 published ten Monographs by Powell (3), Shaler, Russell, Willis, Hayes, Diller, Davis and Gilbert. One year later these were bound together and published by the American Book Company under the title "The Physiography of the United States." In 1898, Ginn and Company published "Physical Geography," an elementary text by William Morris Davis. Thus was launched the modern science of geomorphology and of the regional study of the physiography of the United States.

Davis's "Physical Geography" was written with the belief that the work of rivers and streams could be taught effectively to students in elementary grades. His book had wide popularity, but later texts were so elaborated that they could be taught adequately only by specially trained teachers. This fact and the competition of general science has lost to physiography a distinct field in elementary education. As a separate science it finds but a precarious footing at the university level.

However, the interest in regional physiography has grown through the years and a number of college teachers have prepared notes for courses in this field. A recent count showed that thirty-seven universities list such regional studies, although there is no general agreement as to just what should be covered or where the course should be placed, either by the geologist or the geographer.

Bowman's fine text, "Forest Physiography," 1911, was written to serve as a background for Yale students in forestry. N. M. Fenneman's classic report to the Association of American Geographers, "Physiographic Divisions of the United States," appeared in final form in 1928. His "Physiography of the Western United States," 1931, and "Physiography of the Eastern United States," 1938, both volumes technical and encyclopedic in character, are indispensable for advanced and graduate work. Loomis's brief but interesting elementary text, "Physiography of the United States," was published in 1937. Thus the scope and field of service for any new text in regional physiography becomes a matter of concern, since its wide use will type the training of geologists and geographers.

Dr. Atwood's new text, "The Physiographic Provinces of North America," 1940, is the embodiment of his favorite course as a teacher of physiography in Chicago, Harvard and Clark Universities, and he has brought to the volume his genius for making teaching books, so often shown in the field of geography. Ginn and Company has turned out a fine example of book making. The volume has a color plate and colored maps and in a pocket a large-scale (25 × 40 inches) map of land forms of the United States by Erwin Raisz.

The text assumes an elementary knowledge of geology as a prerequisite, but it is not overburdened with technical terms. It presents the physiographic provinces of North America as the broad basic background for further scientific studies either in geography or geology. It will be read with interest by all who wish to understand the influence of the physical environment upon the history, life and development of the people of North America.

Beginning with a discussion of the regional idea in geography, the chapters follow consecutively and from east to west: the Atlantic and Gulf Coastal Plain; the Appalachian Highlands, New England, Acadian and Southwestern Divisions; The Laurentian Upland; The Central Lowlands; Interior Highlands; Great Plains; Rocky Mountains; Cordilleran Plateaus; and Pacific

Borderlands. A significant list of topographic maps to be consulted is placed at the end of each chapter, together with selected references for additional reading. A laboratory manual to accompany the volume is in preparation.

As would be expected from Dr. Atwood's long study of the region, one of the most important chapters of the book is that on the Rocky Mountains. Here he presents again his belief in the essential unity and late development of the "Rocky Mountain peneplain." While rightly emphasizing the opportunities for the superimposition of rivers from plains of basin filling, as an origin for many canyons in the Rockies, he does not exclude the older idea of antecedent streams for some of the gorges.

The volume is a modernized text in which the landscape is often described as seen from the air, and it is illustrated with superb pictures, especially those taken from aeroplane by Dr. Barnum Brown over the Western United States and by Bradford Washburn in Alaska. Perhaps the most effective teaching device of the book, however, is the number of strip structure-surface diagrams, executed by Dr. Raisz, illustrating cross sections of the physiography of the various provinces. With but few lines, surface and underlying structures are surprisingly well indicated.

Dr. Atwood's volume is an excellent teaching book and it should expand the number of students and of courses offered in the basic study of the physiographic regions of the North American Continent.

ELLIS W. SHULER
SOUTHERN METHODIST UNIVERSITY

PLANT PHYSIOLOGY

Plant Physiology. By BERNARD S. MEYER and DONALD B. ANDERSON. New York: D. Van Nostrand Company, Inc. 1939. $4.50.

THIS book is undoubtedly the outgrowth of a rich experience in the teaching of plant physiology at two prominent American universities and must be classed among the best of the text-books dealing with the various phases of this subject. The thirty-seven chapters of the book are arranged in logical sequence. Prominence has been given in the first few chapters to a discussion of the important properties of solutions and colloidal systems and thus at the outset providing the student with a fundamental background for a better understanding of the biological processes involved in the complex living system. Although no attempt is made to discriminate sharply between the purely physical and the purely chemical characteristics of the subject-matter, the first eighteen chapters deal primarily with the physical phases of plant processes, while the following fourteen chapters are devoted largely to the factors and principles involved in the chemical aspects of plant life. The last five chapters, which deal with the factors involved in growth and movement, are rather brief (perhaps too brief) but may be adequate for the purpose intended. The discussion questions, suggestions for collateral reading and selected bibliographies at the ends of the several chapters have been selected with discrimination and if properly used should develop in the student accurate reasoning, a keen perception of principles involved in physico-chemical processes and an understanding and appreciation of plant physiological material in general. The text material presented is based almost exclusively upon data selected from original sources, and in this a prominent place is given to the discussion of modern developments in plant physiology, without, however, neglecting the older concepts. The book is thoroughly up-to-date, but not particularly historical in its emphasis, a feature which, when the book is used as a class text, affords the instructor excellent opportunity to enrich the discussion of the subjects presented by amplifying the authors' presentation. The text material is presented in a manner so clear and definite that a minimum of efforts is required to understand the authors' meaning, which is never in doubt. A strong feature of this book, as a college text, is a minimum of controversial material and the honest attempt at evaluation of such conflicting evidence as is presented. When theoretical discussions are presented, they are duly stated as such to differentiate them from the purely factual scientific material.

The book is admirably adapted for use with large classes of undergraduates where adequate attention to the individual student by the instructor is only a remote possibility, nor is it too elementary to be exceedingly helpful to the appreciative graduate student in this field. It is a most welcome addition to the growing list of American text-books on this subject and fills a long-felt need for a comprehensive, thoroughly up-to-date college text-book of plant physiology.

JOHN W. SHIVE
RUTGERS UNIVERSITY

REPORTS

PHILANTHROPIC FOUNDATIONS[1]

THE Carnegie Corporation was specifically chartered for the advancement and diffusion of knowledge and understanding, and these words pretty accurately set forth the broad purposes of any non-specialized

[1] Concluding part of the report of Dr. Frederick P. Keppel, president of the Carnegie Corporation, New York, for the year ending September 30, 1940.

American foundation. If this be true, the definite steps these foundations take in the realization of their purposes must of necessity center around inquiry and research for the advancement, and around education, taken in its broadest sense, for the diffusion of knowledge and understanding. Research is a cruelly overloaded word as it is used to-day, and while it may be assumed that an intelligent foundation will not be deceived by obvious misuses of the term, it must be recognized that some of the overloading is due to confused thinking by sincere and earnest people, one example being the efforts of a few years ago to transfer bodily the techniques of the natural sciences into the field of social and educational inquiry.

Certain grants for research have proved, though not always immediately, to be the best of all possible investments for a foundation to make; on the other hand, a research grant may prove to be an almost perfect device for wasting money. It is hard to assign either credit in the first instance, or blame in the second. All along the line the foundation is faced by a series of dilemmas in the selection of research enterprises to support. Here is a field in which the dollar provides no measuring line, for the necessary cost of any particular inquiry is a purely incidental feature which offers no criterion of relative usefulness to mankind. We are told, by those whose own researches have earned them the right to tell us, that nothing is more fatal than an attempt to regiment in any way the spirit of human inquiry, and yet our common sense tells us that the chances of success can not but be enhanced by environmental factors which *can* be controlled, such as adequate equipment, and understanding and stimulating personal contacts.

Fundamental research will always be a highly speculative enterprise, and the present foundation device for selection, while it can certainly be operated more carefully and more intelligently, is in general about as sound as can be hoped for. This device is to get, through consultation with experts, as fair a picture as possible of the fundamental nature of each proposed inquiry, and of the human qualities of the inquirer or inquirers, and then to leave the selection of those to be supported to the lay judgment of the board, decision to be made in terms not only of comparative promise, but also of the funds which the foundation itself may have available, and the chances of support from other sources.

And now, as to the second major channel of productive activity, education. Research can go it alone; education requires public approval and, if possible, public understanding as well. We have to-day the favorable factor of growing public interest in this our largest national industry. In such matters the radio serves as a useful barometer, and it is therefore significant that twenty-four coast-to-coast broadcasts were provided last year for a single educational meeting, that of the American Association of School Administrators. Much, however, remains to be done to clear the public mind as to what the public itself wants from education, and what it can reasonably expect, and by the same token to clarify the teachers' ideas as to what the processes of formal education can and can not do to affect the social order.

In the writer's judgment this whole matter of understanding, alike for the student, the teacher and administrator, and the public at large, must begin by the grasping of two or three fundamental concepts. The first is the enormous range in the native abilities of different individuals. This we "know" in one sense of the word, but we fail to make practical use of our knowledge. It is not so widely "known," but is demonstrably true, that there are corresponding qualitative differences in the various groups of human beings which constitute our universities and colleges and our other types of educational and cultural agencies, and it is equally demonstrable that most people act as if these differences did not exist. A fuller and wider understanding in both instances and a willingness to act in recognition of such understanding might do more than anything else to advance the cause of American education at all levels.

We recognize in our system of professional and vocational training the relationship between what we teach our students and what they must later do to make a living, but we are not nearly so clear as to the relationship between the durable general knowledge and the attitudes which the students acquire throughout their education, and the broad realities and the urgent needs of the adult life they must enter. In this connection the writer takes the opportunity to reiterate his conviction that as a people we have signally failed to get the use we might out of one of our most costly national investments, namely, the great body of our professionally trained men and women. They serve us as individual experts, it is true, but fail to serve as they might as united and influential citizen-groups in our communities. The responsibility for this failure must be laid at the door of education, including adult education.

We are ready to give lip service to the thesis that the logical unit, the center of education, must be the individual student and not the curriculum; but how precise is our thinking on what this means concretely, and how generally do we practice what we preach? How clearly do we grasp the underlying unity of the educative process as a whole, a process beginning for each human being with birth and ending only with death? The lines dividing education horizontally into pre-school, elementary, secondary, higher and adult education, and vertically according to subjects of study, have their usefulness certainly. So have our

parallels of latitude and the meridians of longitude, but it is well to remember that these latter exist only on our maps; we never find them on the face of nature.

If it be true that a foundation of broad charter must of necessity concern itself primarily with matters of research and education, broadly conceived, and if the general considerations thus far presented, and others like them, are valid considerations, we find ourselves facing still another aspect of foundation responsibility. With rare exceptions a foundation can reach its objective only by working through another institution, and there are to-day in the United States far more universities, colleges and other operating institutions, and far more voluntary organizations for worthy purposes than the nation can possibly afford. In the years to come many of these are bound to disappear, and one of the most difficult duties that face the foundation is that of so directing its grants that its influence will be directed toward the survival of the fittest.

These various problems have forced themselves upon our attention during times which, by comparison at least, were normal. The inescapable fact that we are to-day in a tragically disordered world is in itself a further challenge to the foundation to justify its place as a social instrument enjoying exemption from taxation and other valuable privileges. In the face of falling income and increasing calls from every source, will foundations be able to find the things to do upon which their particular assets can be brought to bear most effectively? While they have their limitations, their natural advantages are many. They can move quickly. They can continue their support past the stage of novelty and publicity appeal. They can act with the long view in sight rather than under the pressure of the moment. They can call upon competent and disinterested advice. They can recognize and encourage excellence and the promise of influence and leadership in the individual, the group or the institution. They can find situations which it is to the general interest, but alas nobody's particular business, to clarify by research and experimental demonstrations. It need scarcely be added that no foundation has ever availed itself of these natural advantages to the full. It is equally true, however, that certain of them in the light of their own experience and of a wider public understanding of their responsibilities are each year giving greater weight to these matters in their decisions.

It is hard at any time for a foundation to keep its head amidst exigent and conflicting calls. It is doubly so in times of national tension and excitement—excitement in which, be it remembered, trustees, staff and advisers alike share. It is perhaps hardest, as pointed out in an earlier report, to go on with the familiar tasks, tasks so familiar that we are prone to forget that they may also be essential. Those of us who have had long years of experience in foundation work can not help recalling the errors and missed opportunities of the past, but on the whole, and all things considered, the writer is confident that the American foundation as an institution will meet the double challenge of a critical present and an unpredictable future.

FREDERICK P. KEPPEL,
President

SPECIAL ARTICLES

THE QUANTUM OF SENSORY DISCRIMINATION

THE human organism can detect a change in a stimulus when its intensity is increased by a sufficient increment. This increment alters, presumably, a level of excitation somewhere in the nervous system, and the change in nervous activity leads to a discriminatory response. Problem: Does the change in nervous activity proceed by infinitely small increments or does it proceed stepwise by finite increments or quanta? And are these quanta reflected in the discriminatory response itself?

The classical theory of psychophysics assumes that the frequency with which a given increment in a stimulus will be noticed is governed by the theory of probability,[1] and that an extremely small increment will occasionally produce a discriminatory response. The quantal theory, on the other hand, assumes a limiting value below which an increment will always fail to produce a noticeable difference. The contrast between these two theories is analogous to that between the classical theory and the "quantum theory" of physics.

But the existence of the sensory quantum is difficult to demonstrate. Almost without exception the experimental results conform best to the classical theory: the relative frequency with which an increment is perceived is related to the size of the increment according to a sigmoid function (the normal probability integral). The differential sensitivity of the organism is apparently "normally" distributed in time.[2] The quantal theory proposes that this result is due to the

[1] J. P. Guilford, "Psychometric Methods," McGraw-Hill, 1936, p. 173. Guilford presents Boring's early argument regarding the applicability of probability theory to psychophysics. Boring later suggested the possibility of finding the sort of critical points in a sensory "continuum" which would demonstrate a "quantum theory." See E. G. Boring, *Am. Jour. Psychol.*, 37: 157–188, 1926.

[2] H. C. Montgomery, *Jour. Acoust. Soc. Amer.*, 7: 39–43, 1935.

fact that the experimental procedures are usually such as to mask the differential quantum under a kind of random variability, but that under optimal experimental conditions the quantum can be detected and measured. Békésy[3] achieved results which suggest the existence of a sensory quantum and the present experiment was designed as a further test of the quantal theory.

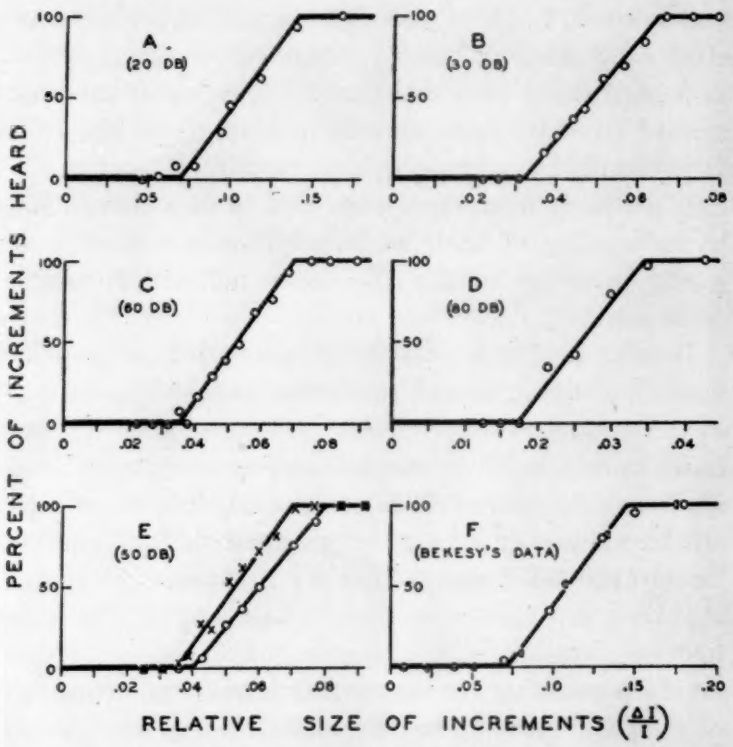

FIG. 1. Functions measuring the quantum of sensory discrimination. The solid lines are the theoretical functions and the points show the obtained frequencies with which various increments in the intensity (sound pressure) of a 1000-cycle tone are heard as increases in loudness. The size of the quantum, measured in terms of the stimulus ratio $\Delta I/I$, is given by the point on the abscissa where the function first departs from zero. The initial intensity, I, of the 1000-cycle tone (in decibels above the observer's threshold) is indicated on each plot, and the number of judgments, N, on which each point is based is indicated below.

Plot A. N = 50.

Plot B. N = 100. This function was obtained with an unfiltered tone, *i.e.*, the transition from I to $I + \Delta I$ was instantaneous. For this reason the *measured* size of the quantum is less than one would predict from plots A and C, where highly filtered tones were used.

Plot C. N = 100.

Plot D. N = 75.

Plot E. N = 50 for each set of data. The circles were obtained at the first sitting. The crosses were obtained after a rest period during which the observer drank a cup of coffee (which may or may not account for the displacement).

Plot F. Békésy obtained the circles for an increase and the half circles for a decrease in intensity (ΔI positive and negative). Békésy's experimental method introduced a systematic error (time-error?) which has been eliminated in Plot F.

[3] G. von Békésy, *Ann. d. Physik*, 7: 329–359, 1930.

Békésy presented a tone lasting 0.3 seconds., followed immediately by a second tone of the same duration but of variable intensity. In our experiment the observer listened to a continuous 1,000-cycle tone whose intensity was momentarily increased at intervals of 3 sec. The increase lasted 0.15 sec. The observer's task was to press a key whenever he heard an increase in loudness and to refrain from pressing the key when no change was detectable.

Results for a well-practiced observer (Volkmann) are pictured in Fig. 1. Two features of these curves should be noted: (1) The functions between 0 per cent. and 100 per cent. are rectilinear; they obviously do not conform to the normal probability integral—the phi function of gamma. (2) The point on the abscissa where the function reaches 0 per cent. is exactly one half of the value at which it reaches 100 per cent. The solid lines in Fig. 1 give the values predicted by the quantal theory on the assumption that the observer hears an increase in loudness whenever the level of nervous excitation is increased by an amount equal to *two* quanta. The argument is as follows.[4]

At a given moment the steady stimulus excites completely a certain number of neural quanta and leaves a sub-quantal *surplus* which "partially" excites some additional quantum. Due to an over-all fluctuation in the sensitivity of the organism—a fluctuation large compared to the size of a quantum—the time-distribution of the amount of this surplus is sufficiently random so that, at any instant, one amount of "partial" excitation is as likely as another. Now, the stimulus increment, ΔI, required to excite completely this "partially" excited quantum is smaller when the surplus is larger. Or, if we measure, as we must, the size of the quantum in terms of the increment, ΔI_q, which will *always* excite it, the ΔI just sufficient to complement the "partial" excitation and thereby excite an additional quantum is given by

$$\Delta I = \Delta I_q - p \qquad (1)$$

where p is the amount of "partial" excitation. A given ΔI will excite an additional quantum whenever $\Delta I \geqq \Delta I_q - p$. And since p fluctuates at random between $0 \leqq p \leqq \Delta I_q$, this condition will obtain a proportion of time given by

$$f_1 = \frac{\Delta I}{\Delta I_q} \qquad (2)$$

where f_1 is the relative frequency of the instants during which ΔI excites one additional quantum. The value of f_1 varies between zero and one.

Now, if *two* added quanta are needed to produce a just noticeable difference in loudness, equation (2) becomes

[4] See also S. S. Stevens and H. Davis, "Hearing," Wiley, 1938, p. 145–147.

$$f_2 = \frac{\Delta I - \Delta I_q}{\Delta I_q} \quad (3)$$

and f_2 again varies only between zero and one.

Or, in terms of the percentage, P, of the increments which an observer should hear as increases in loudness

$$P = \frac{\Delta I - \Delta I_q}{I \Delta_q} \times 100 \quad (4)$$

and P varies between zero and 100.

The functions in Fig. 1 fit equation (4) provided we interpret ΔI_q as the abscissa value where the functions first depart from 0 per cent. This value measures, in terms of the stimulus, the size of the differential quantum for loudness discrimination.

The conventional procedure is to measure differential sensitivity in terms of the 50 per cent. point on the functions in Fig. 1, but this measure gives a value half again as large as the differential quantum.

Békésy's procedure enabled him sometimes to get discriminations based upon the addition of a single quantum. After many hours of practice he obtained a rectilinear function parallel to that in Fig. 1 F, but intersecting the abscissa at zero. Under our own procedure a discrimination requires the addition of two quanta because the excitation due to the continuous tone against which the observer makes his judgments fluctuates up and down at random by single quantal jumps. From this "steady" tone condition only double quantal jumps can be discriminated.

It is important, finally, to emphasize the difficulties involved in measuring the differential quantum. Data fulfilling exactly the predictions of equation (4) are the exception, not the rule. Usually one obtains sigmoid functions, because almost any kind of "error" in the experiment tends to move those points lying near the elbows of the function farther toward the 50 per cent. region. Compensatory errors tending to move points to a position below 0 per cent. or above 100 per cent. can not, of course, occur. Also, if the size of the quantum changes during an experiment the process of averaging produces a sigmoid function. Thus the data in Fig. 1 E, obtained in two different experimental sessions, would, if averaged, reduce to a sigmoid curve. As it is, these two sets of data fit rectilinear functions whose slopes are those required by equation (4).

It is of crucial importance that the interval of time between the presentation of the standard stimulus, I, and the comparison stimulus, $I + \Delta I$, be short. Data satisfying equation (4) are not obtained when the over-all sensitivity of the organism is allowed to change during the interval between the two stimuli.

Given an adequate experimental procedure in which these and other factors are kept favorable, it is apparently quite possible to reduce the random variability expected under the classical theory to the restricted variability predicted by the quantal theory of sensory discrimination. The confines of this restricted variability provide a stimulus-measure of the differential quantum.

S. S. STEVENS
HARVARD UNIVERSITY

J. VOLKMANN
COLUMBIA UNIVERSITY

A NEW ESTROGENIC SUBSTANCE PRESENT IN THE NEUTRAL FRACTION OF HUMAN PREGNANCY URINE[1]

THREE well-defined crystalline substances have been isolated from human pregnancy urine. These substances, estrone, estradiol and estriol, each have among other similar chemical properties a phenolic hydroxyl group in position three of ring A.[2,3,4] By virtue of this property these substances are soluble in alkali and may be extracted from an ether solution by means of an aqueous solution of sodium hydroxide. This communication deals with an estrogenic substance in human pregnancy urine which can not be extracted by aqueous alkali from an ether solution and, therefore, appears to be a neutral substance.

The pregnancy urine concentrates employed in this study have been prepared by two different procedures. The concentrates employed in experiments numbers 1 and 2 (Table I) were prepared as previously described.[5] This method involves the extraction of acidified boiled urine with benzene. The acidic and phenolic substances are separated by means of a 10 per cent. aqueous solution of sodium hydroxide. The neutral fraction or alkali insoluble fraction was then subjected to repeated extraction with aqueous 10 per cent. sodium hydroxide as indicated in Table I. The concentrate used in experiment number 3 was prepared by

TABLE I

Experiment number	Quantity of human pregnancy urine Liters	Number of separations* with 10% NaOH	Estrogenic activity in alkali-insoluble fraction I.U./Liter
1	11	30	52
		55	55
		80	48
2	12	50	21
3	3,800	70	20

* These separations were carried out by dissolving the extract in ether and extracting the ether layer with an equal volume of 10 per cent. aqueous sodium hydroxide.

[1] Aided by grants from the Committee on Scientific Research of the American Medical Association and the Rockefeller Foundation.

[2] S. A. Thayer, L. Levin and E. A. Doisy, *Jour. Biol. Chem.*, 91: 791, 1931.

[3] D. W. MacCorquodale, S. A. Thayer and E. A. Doisy, *Jour. Biol. Chem.*, 99: 327, 1933.

[4] G. V. Smith, O. W. Smith, M. N. Huffman, S. A. Thayer, D. W. MacCorquodale and E. A. Doisy, *Jour. Biol. Chem.*, 130: 433, 1939.

[5] R. I. Dorfman, J. W. Cook and J. B. Hamilton, *Jour. Biol. Chem.*, 130: 285, 1939.

extracting the acidified urine with butanol and concentrating the butanol in vacuum. The concentrate was then subjected to alkaline hydrolysis followed by acidification to the neutral point and extraction with ethyl ether. The phenolic compounds were separated by extracting the ether solution with dilute alkali. The neutral fraction was chilled in order to remove the bulk of the pregnanediols.[6] This alkali insoluble fraction was dissolved in ethyl ether and subjected to repeated extractions with aqueous 10 per cent. sodium hydroxide as represented in Table I.

All essays for estrogenic activity were performed on the adult spayed mouse in parallel with estrone. All values are expressed in International Units (I.U.)

In Table I we see that after exhaustive extraction of an ether solution containing principally alkali insoluble substances with a solution of sodium hydroxide, between 20 to 55 I.U./liter of estrogenic activity is still detectable in the concentrate of neutral compounds. That this estrogenic activity is not merely due to some phenolic estrogen has been demonstrated by two experiments. First, as the number of extractions with alkali of the ether phase is increased from 30 to 55 and finally to 80 in experiment 1, no significant decrease in estrogenic potency of the neutral fraction could be demonstrated. Second, when 3 mgm of estrone (30,000 I.U.) were added to a concentrate of neutral compounds from normal female urine, less than 25 I.U. of estrogenic activity was found to be present in the neutral fraction after 20 separations with alkali.

Since it is well known that dehydroisoandrosterone, which has been isolated from human pregnancy urine, has certain estrogenic effects, it becomes necessary to inquire as to the possible role of this substance in these observations. A portion of the concentrate containing 1080 I.U. of activity prepared in experiment 3 after 70 separations with alkali was separated into ketonic and non-ketonic fractions. The ketonic fraction which contains the dehydroisoandrosterone assayed less than 300 I.U. while the non-ketonic fraction contained the bulk of activity or more than 800 I.U. Thus it appears that the principal estrogenic activity resides in the neutral non-ketonic material. Further work is under way to ascertain more of the chemical and physiological properties of this material.

Summary

In addition to the well-defined phenolic estrogens in human pregnancy urine there appears to be another estrogenic substance which is a neutral non-ketonic compound.

RALPH I. DORFMAN

YALE UNIVERSITY SCHOOL OF MEDICINE

[6] Thanks are due to Dr. O. Kamm of Parke Davis and Company for carrying out this procedure.

CONCENTRATION AND PARTIAL PURIFICATION OF EQUINE ENCEPHALOMYELITIS VACCINES[1]

CHICK embryo vaccines[2] employed in the immunization of horses against the virus of equine encephalomyelitis and, in special instances, for human vaccination,[3] have consisted thus far of crude saline extracts of virus-diseased tissue containing about 0.4 per cent. formalin. The quantity of vaccine given, usually a total of 20 cc of a 2 per cent. extract for horses and 4.0 cc for man, has been determined by quantitative relations with respect to the physical amount of immunizing principle present in them. With the necessary amount of specific antigen, there have been introduced simultaneously relatively large quantities of inert chick embryo material and formalin. A high degree of concentration and purification of the immunizing principle can be accomplished,[4] though on an impractical scale, by ultracentrification. Recent experiments have shown that the virus of equine encephalomyelitis is insoluble[5] in acid solutions of hydrogen ion activity not injurious[6] to the virus in brief periods. The antigenic formalin derivative[7] of the purified virus is likewise insoluble under similar conditions and can be sedimented quantitatively in the ordinary angle centrifuge. On the basis of these findings a greatly concentrated and partially purified vaccine has been prepared by procedures suitable for practical application.

Chick embryo vaccines were prepared in the routine way by adding formalin to 0.4 per cent. concentration to a 20 per cent. suspension of virus-diseased chick embryo tissue in Ringer solution. When inactivation of the virus was complete, the suspension was adjusted to pH 7.5 and cleared of gross material by spinning in the angle centrifuge at about 4,000 g for 30 minutes. By the addition of 0.2 N hydrochloric acid, the pH of the resulting supernatant fluid was reduced to 4.8 and the turbid suspension was immediately spun in the angle centrifuge at 4,000 g for 30 minutes. This supernatant fluid was discarded and the sedimented material taken up in Ringer solution so that the total volume was one tenth that of the initial volume of crude vaccine. The pH was immediately brought to

[1] This work was supported by a grant from Lederle Laboratories, Pearl River, N. Y., and by the Dorothy Beard Research Fund.

[2] J. W. Beard, H. Finkelstein, W. C. Sealy and R. W. G. Wyckoff, SCIENCE, 87: 490, 1938.

[3] J. W. Beard, D. Beard and H. Finkelstein, *Jour. Immunol.*, 38: 117, 1940.

[4] J. W. Beard, H. Finkelstein, W. C. Sealy and R. W. G. Wyckoff, SCIENCE, 87: 98, 1938.

[5] A. R. Taylor, D. G. Sharp and J. W. Beard, *Jour. Infect. Dis.*, 67: 59, 1940.

[6] H. Finkelstein, W. Marx, D. Beard and J. W. Beard, *Jour. Infect. Dis.*, 66: 117, 1940.

[7] D. G. Sharp, A. R. Taylor, H. Finkelstein, D. Beard and J. W. Beard, *Proc. Soc. Exp. Biol. and Med.*, 43: 650, 1940.

7.0 by the addition of 0.5 N ammonium hydroxide. The concentrate thus obtained has approximately the same nitrogen content per unit volume as the crude vaccine indicating the elimination of 90 per cent. of the total protein originally present. A comparable proportion of formalin is also discarded in the acid supernatant fluid.

TABLE 1

IMMUNIZATION OF GUINEA PIGS WITH CONCENTRATED AND PARTIALLY PURIFIED WESTERN STRAIN EQUINE ENCEPHALOMYELITIS VACCINE

Preparation	Dose† cc	Route	Test for immunity‡	
			Vaccinated	Control
Crude vaccine	0.5	Subcu.	4/4	
Concentrated vaccine	0.1	"	5/5	
	0.05	"	5/5	
	0.1 *	"	3/3	0/5
	0.05*	"	5/5	
	0.1	Int. derm.	5/5	
	0.05	"	4/4	

† The amount given in each of 2 injections with an interval of 7 days.
‡ 500–1,000 mouse infectious units of virus were given intracerebrally 14 days after the second injection of vaccine. The numerator indicates the number of animals surviving the challenge dose and the denominator the number of animals in the test.
* Diluted to corresponding volume of crude vaccine.

The capacity of a Western strain vaccine concentrate to immunize guinea pigs is illustrated by the results of a typical experiment shown in Table 1. Similar experiments have been made in which the effectiveness of smaller volumes of crude vaccines was compared with that of corresponding volumes of concentrated vaccines. The results have shown that, within the limits of the immunological tests, the immunizing principle is quantitatively concentrated and not damaged by precipitation in acid solution. This is substantiated by examination of the concentrate with the analytical ultracentrifuge. Like findings were obtained with Eastern strain material similarly prepared.

As shown in Table 1, the concentrated material confers protection, whether it is given subcutaneously or intradermally. The small volumes of it containing an effective immunizing dose are compatible with the practical utilization of the concentrated vaccine through routine intradermal administration.[8] The elimination of most of the formalin and chick embryo protein associated with the necessary amount of vaccine may be of considerable significance with respect to lessening or abolishing reactions sometimes attending the vaccination of horses[9] and man,[10] especially following the second or subsequent course of injections of crude vaccines. Of still greater promise in this direction are the possibilities associated with combination of intradermal injection and the greatly reduced quantities of formalin and inert protein.

A. R. TAYLOR
D. GORDON SHARP
DOROTHY BEARD
H. FINKELSTEIN
J. W. BEARD
DUKE UNIVERSITY SCHOOL OF MEDICINE

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN A-C POWERED PH SET

ONE method to determine the PH of a solution is to measure the EMF developed between a glass PH electrode and an "indifferent" electrode, both placed in the solution. This EMF is of the order of a few tenths of a volt and changes about 60 millivolts per PH unit. In practice any steady component of this EMF may be balanced by means of a potentiometer in series with the indifferent electrode. The changes of EMF, which reflect the changes of PH, are observed and recorded by suitable apparatus. Such an apparatus is commonly called a current amplifier or an impedance changer, though the latter term is a misnomer. The chief requirements of such a device are (1) that it have high input impedance, and (2) that it not fluctuate spontaneously. An A–C powered current amplifier which fulfils these conditions is described below.

In Fig. 1, the controlling voltage is applied to the third grid of a 6J7 pentode tube. This grid is biased about 3 volts negative, the second grid and the plate are each about 25 volts positive. The first grid is tied to the cathode. Thus the usual connections of G_1 and G_3 are interchanged. The effect of G_3 then is to change the distribution of current between G_2 and the plate.

Fig. 2 illustrates 3 possible paths for an electron after it leaves the cathode: (A) it may go straight to screen; (B) it may go through screen and G_3 and on to plate; (C) it may go through screen and be so repelled by negative G_3 that it is sent back to the screen.

If G_3 is now made more negative, the number of electrons following path C will be increased and the number following path B will be correspondingly decreased. Thus screen current increases, plate current decreases, but the sum of the two remains constant. Now, it is the difference of plate and screen currents that affects the galvanometer G.

Any disturbance in the tube, such as a change in cathode emission, or a change in B supply voltage, will affect both plate and screen currents in the same direction, but will have little effect on their differ-

[8] H. W. Shoening, M. S. Shahan, O. L. Osteen and L. T. Giltner, *Vet. Med.*, 35: 377, 1940.
[9] H. W. Shoening, *Jour. Amer. Vet. Med. Asn.*, 97: 39, 1940.
[10] D. Beard, H. Finkelstein and J. W. Beard, *Jour. Immunol.* In press.

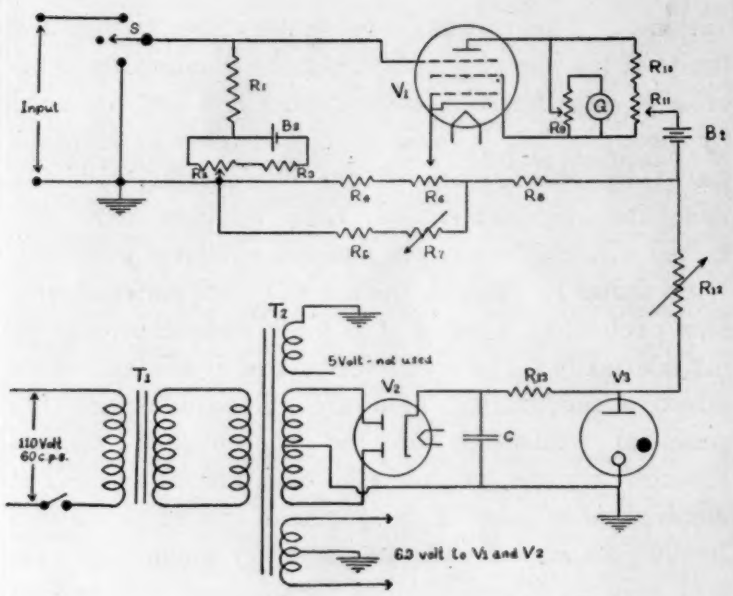

FIGURE 1

R_1	100 meg	S S white 65 X Resistor				
R_3	10 meg	"	"	"		
R_4	500 ohm	International	Resistance	Co.—Type	A	B Resistor
R_5	2000	"	"	"	"	"
R_8	2000	"	"	"	"	"
R_{10}	5000	"	"	"	"	"
R_{13}	7500	"	"	"	"	"
R_2	1 meg			Potentiometer	(on	panel)
R_6	200 ohm	(Yaxley X)		"	"	"
R_7	200	"	"	"	"	"
R_9	20000	"	A–20–MP	"	"	"
R_{11}	5000	"	A –5–MP	"	(behind	panel)
R_{12}	10000	"	A–10–MP	"	"	"
S	switch	"	161–C (on panel)			

C 8 μfd 450 volt electrolytic condenser
T_1 constant voltage transformer (Sola 3000)
T_2 Thordarson T 13R19 transformer
V_1 RCA 6J7 in Steatite socket (Amphenol R–SS–8)
V_2 6 X 5 tube
V_3 VR–105 tube
G galvanometer

One PH unit or 60 millivolts input will cause 8 microamperes to flow through G when R_9 is set at maximum sensitivity. Thus the required galvanometer sensitivity can be calculated in terms of the PH range it is desired to cover.

ence. Hence the galvanometer is not much affected by such disturbances.

The response of the galvanometer to changes in filament voltage can be reduced nearly to zero by the proper adjustment of R_{11}.

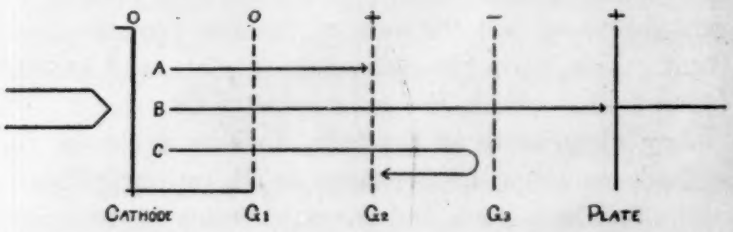

FIGURE 2

If a small extra source of voltage such as a battery be inserted in series with the plate and screen supply, it becomes possible to adjust R_{12} so that the set is practically insensitive to changes in B voltage. The effect of fluctuations of B voltage is always small, however, and the above expedient may not be necessary. We find 1.5 to 4.5 volts suitable for the battery.

The resistor R_6 is used to adjust to free grid—*i.e.*, so that the galvanometer does not shift as the switch is rotated from the short to the open position. The grid current, however, is always very small in this tube, so this adjustment and the bias cell might well be omitted.

We have used RCA 6J7 tubes. They must be selected, as they are not uniform. The shell must be grounded—not connected to cathode. 6SJ7 and 6J7-G tubes have not been satisfactory.

The important features of this design are (1) the push-pull connection between plate and screen of a single tube, and (2) the cascaded use of several devices to secure isolation from line voltage variations.

In the present design we have (1) the regulating transformer, (2) the gaseous discharge tube, (3) the push-pull connections. None of these would be good enough alone to absorb line voltage variations completely and provide stable operation. Since each of these devices gives only a moderate degree of isolation, none is critical in design or adjustment.

If the whole task of isolating the set from the line depended on one regulator or one push-pull connection this would involve a quite critical adjustment. Such an adjustment might be subject to spontaneous drifts. The cascade circuit gives ample isolation with no critical parts.

Since most experimenters wish to record PH over a relatively long period of time, the elimination of batteries without loss in stability will prove to be a convenience.

CRAIG W. GOODWIN

YALE UNIVERSITY

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